CONTRIBUTIONS

FROM THE

CUSHMAN LABORATORY

FOR

FORAMINIFERAL RESEARCH

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22. PHOTOGRAPHING FORAMINIFERA

By Joseph A. Cushman

The methods of photographic work as developed in this laboratory are now being used with success elsewhere. It is perhaps best to give in some detail the methods used that they may have a wider use as they are of very great service in the study of the foraminifera, especially in economic work where much detailed data should be quickly available in visual form.

Various methods have been tried out for a number of years, but always difficulty was encountered in getting sufficient depth of focus with the desired magnification. Several years ago a method was worked out by the writer, and later put into definite form. It has continued to give excellent results. The main idea has been to obtain a negative of the greatest possible depth of focus regardless of magnification, and then the enlargement from this negative to the desired size. In this way the details are kept with the deep focus.

For the actual photographing, a vertical camera is used. The particular camera used in the laboratory is a type "H," Bausch and Lomb, with the camera parts to take 5x7 plates. Kits are used in the plate holders for smaller sizes. Any good compound microscope may be used. For objectives the Micro-Tessars of Bausch and Lomb are used. The 32-millimeter equivalent focus has been found to be of the greatest value although those of greater focal length are excellent for larger specimens. For focusing, the diaphragm should be wide open or nearly so, but for the actual exposure the stop should be cut down at least to 11 of the scale, or even to 22 to get the greatest possible sharpness and depth. An ocular may be used if desired, but much the best results are obtained without it. With the type "H" camera with the bellows extended to full length there is a magnification of the image on the plate to about 18 to 20 diameters.

This will give an excellent depth. By all means a focusing glass of some form should be used, and every change of specimens very carefully refocused. The entire result depends on this point of very exact focus. With the combination of a 32-millimeter, no ocular, and bellows full length all the specimens in a circle of about 5 millimeters may be photographed at once.

For the lighting, one of the regular Bausch and Lomb illuminating outfits with a 6-volt, 108-watt lamp is used. This is placed in the most advantageous position, and then screwed to the table to form a permanent fixture with a table switch. With the microscope and camera fixed, the only thing needed is to get the slide in position. The light from this unit will be found very intense and the shadows it casts very dark. In the laboratory here a counter-light is used. This is a 250-watt, 115-volt "floodlight" bulb in an ordinary pliable gooseneck which can be quickly bent to any desired position.

In actual operation a table was built in across the end of the "exposure room" of the laboratory, the centre of the top removable with a second solid shelf below. In this lower part the camera and microscope are placed, and the counter-light. On the top at the left is the strong light as already noted. This arrangement brings the top of the camera when extended low enough so that focusing can be done from the floor. A medium position is thus obtained obviating stooping to place the slides in position and change the diaphragm, and also standing on a higher level for focusing.

When these factors already mentioned have become fixed a table of variant factors should be worked out. The intensity of the strong light may be varied by focusing, and this will greatly change the time of exposure. The greatest speed can be obtained with the filament just out of focus on the slide. Each new bulb will be found to vary sometimes as much as fifty per cent, and the intensity is apt to decrease with use. This factor must be constantly checked. Specimens will require very different exposures. White foraminifera of tropical reefs containing chalk white Miliolidae will need much less exposure than the gray, dull material of much of the American Cretaceous for example. Length of exposure should be increased rather than opening the iris diaphragm.

The best results will be obtained from fairly slow plates, and any good plate will give excellent results. The normal development time for the plate should be taken as the base and length of exposure, intensity of light, etc., varied until the desired

sharpness of the developed plate results. Tank development is used entirely.

When good negatives are obtained the next step is to get the size best adapted to the purpose desired. In this work an Eastman auto-focus enlarging camera is used. With this camera working in a vertical position no focusing is necessary, and the enlarging paper placed directly on the table in the red light, with a smaller auto-focus enlarger a magnification of 3½ times may be obtained, making the final print 60 to 75 diameters, a size sufficient for all practical purposes. Where records are desired for filing in the laboratory, printing is done on double thick, 4x6 paper, which can then be used as a 4x6 file card with any notes that may be necessary.

By the methods outlined here we have photographed 2,500 specimens of foraminifera in an afternoon on less than a hundred slides, and had the negatives ready for printing in the evening if necessary.

The longest time is spent in mounting the slides for photographing, but if flat slides are used with a black background gummed ready for use, one quickly becomes very expert in placing the specimen in position and arranging a number in the 5-millimeter circle. Specimens of fairly uniform size should of course be mounted together to insure uniform focus.

This method proved by several years of constant usage here in the laboratory will be found a very valuable one wherever numbers of foraminifera are handled, and where permanent records are desired.

23. EOUVIGERINA, A NEW GENUS FROM THE CRETACEOUS

By Joseph A. Cushman

In material from the Taylor Marl of the Upper Cretaceous of Texas, kindly furnished by Mrs. Helen J. Plummer, there are numerous small forms, which are of especial interest. They are very clearly related to *Sagrina cretacea* Heron-Allen and

Earland and to *S. aspera* Marsson, both of which are known from the Upper Cretaceous of Europe. A study of the developmental stages of the two species from the Taylor Marl shows that they have very interesting relationships with several known genera. The early development seems to be, at least in the microspheric form, a series of coiled chambers such as are found in the microspheric form of *Bolivina* and *Textularia*. Later chambers are biserial, but the last-developed ones in the adult instead of keeping to the biserial form often become triserial and may be compared to *Uvigerina*. The development of a definite neck and phialine lip also makes them resemble *Siphogenerina*, *Uvigerina*, and *Trifarina*. It seems rather clearly indicated that the genus *Uvigerina* may have developed from just such forms as these through the process of acceleration of development, the shoving back of this adult character of a triserial arrangement into the earlier and earlier stages. Such a form would directly result in typical *Uvigerina*. The genus and species are here described after which further discussion of their relationships are given.

Genus EOUVIGERINA Cushman, new genus

Test free, elongate, the early chambers, at least in the microspheric form, coiled, later chambers becoming biserial, final chambers irregularly triserial; aperture circular or rhomboid at the end of a definite neck usually with a phialine lip. (Genotype *Eouvigerina americana* Cushman, n. sp.)

EOUVIGERINA AMERICANA Cushman, n. sp.

Plate 1, figs. 1 *a-c*

Test elongate, tapering, greatest breadth toward the apertural end, composed of numerous chambers, the early ones somewhat compressed, coiled, forming one volution or less in the microspheric form, chambers of the adult mostly biserial but the last-formed ones in fully developed specimens leaving the biserial form and becoming triserial; chambers distinct, polygonal, the upper face flat or slightly convex, the sides concave making a definitely angled chamber with a sharp periphery on the upper edge, the edges of the chamber with a trace of a keel in the adult; sutures distinct and depressed, especially in the later development; wall unornamented; aperture rhomboid, at the end of a short neck with a phialine lip.

Length 0.35 mm.; breadth 0.18 mm.; thickness 0.12 mm.

Holotype (Cushman Coll. No. 4986), from the Upper Cretaceous, Taylor Marl, Clay pit of Dallas Brick Co., ½ mile west of Mesquite, Texas, collected by Helen J. Plummer.

This species is most closely related to *Eouvigerina cretacea* (Heron-Allen and Earland) (Journ. Roy. Micr. Soc., 1910, p. 423, pl. 8, figs. 8-10), described from the Chalk of England. The American species, however, differs in the much more angular chambers which are not nearly so convex, and the whole test has the chambers more loosely put together.

EOUVIGERINA GRACILIS Cushman, n. sp.

Plate 1, figs. 2 *a-c*

Test elongate, slender, tapering, greatest width formed by the last 2 chambers, earliest chambers obscure but the test for the most part made up of biserial chambers, those of the adult last formed become triserial and more isolated from one another; chambers nearly round in transverse section, inflated; sutures distinct, much depressed; wall roughened by minute spines; aperture rounded at the end of a short, cylindrical neck with a rather broad phialine lip.

Length 0.35 mm.; breadth 0.13 mm.; thickness 0.10 mm.

Holotype (Cushman Coll. 4988), from the Upper Cretaceous, Taylor Marl, Clay pit of Dallas Brick Co., ½ mile west of Mesquite, Texas, collected by Helen J. Plummer.

This is nearest to *Eouvigerina aspera* (Marsson).

As has already been shown elsewhere the genus *Sagrina* being in much doubt from the fact that the type species of the genus, *Sagrina pulchella* d'Orbigny, is probably a *Bolivina* has made *Sagrina* unavailable for use for such forms as these under consideration. They do not belong typically in *Siphogenerina* because there is no tendency to develop a uniserial group of chambers in the adult, but instead, the development of a triserial group much more like that developed as a typical adult character in *Uvigerina*. As it is quite possible that *Uvigerina* may have developed from such forms, the generic name *Eouvigerina* is here given to them. From what has already been noted the genus is evidently widespread in the later Upper Cretaceous, at least of America and Europe. The small size would make them easily overlooked. In this connection it is interesting to note that the one *Uvigerina* described from the American Cretaceous, *U. seligi* Cushman (Contrib. Cushman

Lab. Foram. Res., vol. 1, pt. 1, 1925, p. 1, pl. 4, figs. 1 *a-c*), described from the Arkadelphia Clay is also very small, being even less in length than either of these species of *Eouvigerina*. The genus *Eouvigerina* is closely related to *Siphogenerina*, *Uvigerina*, and *Trifarina*, and it seems that they should be grouped together under the subfamily Uvigerininae. The *Uvigerina* group has usually been classed with the family Lagenidae. However Silvestri has placed under the subfamily Bulimininae in his family Ellipsoidinidae the genus *Siphogenerina* Schlumberger. The peculiar apertural characters with cylindrical neck and phialine lip are distinctive from the other genera grouped under the subfamily Bulimininae. The internal tube connecting the chambers is present in *Siphogenerina* and in at least some of the species of *Uvigerina*, and occurs in *Trifarina*. This would then take *Uvigerina* and the subfamily Uvigerininae from the family Lagenidae and place it under Silvestri's new family Ellipsoidinidae. The Lagenidae will then be left as a much more definite group, characterized by the glassy type of chamber wall, with a definite radiate aperture except in the group characterized by *Lagena* itself. In this connection it may be noted that the derivation of *Eouvigerina* and the other genera of this group from *Bolivina* is not a very radical step. Most of the Cretaceous Bolivinas are not greatly compressed as is the case in so many of the Tertiary and Recent ones. The development of a cylindrical neck and phialine lip in *Bolivina eocenica* Terquem, as figured by Heron-Allen and Earland (Journ. Roy. Micr. Soc., 1911, pl. 10, figs. 6, 7) would indicate the close relationship of these two groups. Another point which may show that the relationships of *Uvigerina* and the Bulimininae are more closely related than might at first be suspected is shown especially by the Uvigerinas of the Tertiary of our own West Coast where there are developed species in which the apertural characters show a decided deviation from the usual form. Instead of the cylindrical neck there are developed forms with a high "collar," which is open on the side toward the axis of the test. These forms also instead of having the typical circular aperture have a much elongate one, not unlike that seen in some species of *Bolivina*. As an added feature the aperture frequently develops a decided tooth in which it resembles some forms of *Bolivina*.

24. THE GENUS LAMARCKINA AND ITS AMERICAN SPECIES

By JOSEPH A. CUSHMAN

In 1881 Berthelin (C. R. Assoc. Franc. (Reims, 1880) 1881, p. 555) proposed the generic name *Lamarckina* with the type species *Pulvinulina erinacea* Karrer, from the Miocene of Kostej in the Banat region of Hungary. This name has not been used by later authors, but a comparison of specimens of *P. erinacea* Karrer from the type locality with several species of our American Tertiary and elsewhere makes it very advisable to use this generic name *Lamarckina* for the very definite group it includes.

Genus LAMARCKINA Berthelin, 1881

Lamarckina BERTHELIN, C. R. Assoc. Franc. (Reims, 1880) 1881, p. 555. [Genotype *Lamarckina erinacea* (Karrer).]

Test evidently attached in life, coiled, composed in the adult of about 1½ coils, dorsal side with the chambers all visible, ventral side with only those chambers of the last-formed coil visible, dorsal side convex and either smooth or variously ornamented, ventral side flattened or slightly concave, the whole surface very smooth and highly polished or at least such part of it as forms the attachment; chambers distinct on the dorsal side, less so on the ventral; sutures simply curved, slightly depressed or sometimes raised on the dorsal side, on the ventral slightly depressed; wall finely perforate, the ventral side thickened and the perforations less evident; aperture umbilical, large, usually with a projection partially covering the aperture itself, in earlier chambers as covered the aperture is enlarged by resorption.

The attached form is evidenced by the "humping" up of the newly added chambers, and the very smooth polished ventral surface which may be compared in appearance to the highly polished portions of some molluscs.

The type species, *Lamarckina erinacea* (Karrer), as already noted is from the Miocene of the Banat Region of Hungary. The genus is represented by species in the Upper Cretaceous, all the main divisions of the Eocene, and the Lower Oligocene of America, in Eocene and later Tertiary of other regions, and also occurs in the present oceans. The generic characters are closely held from the Upper Cretaceous onward. The descriptions of the American fossil species follow.

LAMARCKINA RIPLEYENSIS Cushman, n. sp.

Test longer than broad, dorsal side convex, ventral side flattened, consisting of about 1½ coils, 8-9 chambers in the last-formed coil; chambers very distinct, only slightly inflated; sutures distinct, limbate, raised, the inner end being more distinct than the peripheral end; periphery carinate, the carina fusing with the raised sutures; surface between, rather coarsely punctate, ventral side smooth and highly polished, umbilicate, the last-formed chamber with a large semicircular lip above the aperture; sutures and chambers hidden by the smooth, secondary thickening of the ventral side.

Length 0.50 mm.; breadth 0.40 mm.; thickness 0.20 mm.

Type specimen (Cushman Coll. No. 5129) from the Cretaceous, Ripley formation, Owl Creek, Mississippi, collected by Helen J. Plummer.

This species kindly furnished me by Mrs. Plummer carries the history of this genus back into the Upper Cretaceous. It may be distinguished from all the other species by the carinate edge combined with very prominently raised sutures and the peculiar, coarsely punctate appearance of the dorsal surface between the sutures. It also differs from other species of the genus in having a large number of chambers in the coil, the average probably being around 7 in other species where this has 8 or 9. Figures of this species will be given in Part 2 of these Contributions.

LAMARCKINA RUGULOSA Plummer, MS.

Plate 3, figs. 6 *a-c*

Test very broadly elliptical to almost round in outline, moderately compressed in average development to nearly globular in extreme old age; convolutions not over 1½; chambers 5-6 in the last-formed whorl, enlarging rapidly, very smooth and glistening on the ventral face, highly granular on the dorsal face; dorsal sutures slightly depressed between last 2 or 3 chambers, but commonly obliterated by the granulations, or rarely marked by faint ridges of smooth shell material; ventral sutures faintly depressed; umbilicus deeply excavated; aperture a low arch on the umbilical edge of the final chamber under a narrow and delicately fringed flap on well-preserved tests.

Maximum length up to 0.50 mm.; maximum breadth 0.40 mm.; thickness 0.30 mm.

Cotypes (Cushman Coll. No. 5111), Lower Eocene, Midway,

from a road-cut south of city reservoir, 3½ miles S. E. of Corsicana, Texas, collected by Helen J. Plummer.

This species also occurs in the Lower Eocene, Clayton formation, from a bluff on the south side of Owl Creek, 2¾ miles N. E. of Ripley, Tippah Co., Mississippi, collected by C. Wythe Cooke.

Lamarckina rugulosa, although one of the smallest of the American species, is very distinct in its rugose dorsal surface and the broadly rounded periphery, as well as the fact that the smooth character of the ventral surface, which extends up onto the dorsal surface at the peripheral end, is seen in the line of coiling on the dorsal surface.

LAMARCKINA WILCOXENSIS Cushman, n. sp.

Plate 1, figs. 3 *a-c*

Test small, thick, slightly longer than broad, periphery sharply angled, slightly lobulate, last-formed coil consisting of about 7 chambers, dorsal side broadly convex, smooth, umbonate; chambers inflated, but the central early chambers forming a distinct umbo; sutures depressed or occasionally limbate, ventral side somewhat convex, strongly umbilicate, smooth and highly polished; aperture with an elongate projecting area from the last-formed chamber.

Length 0.35-0.40 mm.; thickness 0.25 mm.

Type specimens (U. S. N. M. Coll. No. 354035) from Wilcox formation, Woods Bluff, Tombigbee River, Ala., collected by E. A. Smith.

This may be distinguished from all the following species by its smaller size, greater thickness, and smooth dorsal surface.

LAMARCKINA MARYLANDICA Cushman, n. sp.

Plate 1, figs. 5 *a-c*

Test subcircular in outline, periphery lobulate, generally planoconvex, 7 chambers in the last-formed coil, dorsal side broadly and evenly convex, the sutures especially in the earlier portion raised above the otherwise smooth surface and coalescing, ventral side strongly umbilicate, very smooth and highly polished; aperture large, somewhat more oblique than some of the other species.

Diameter 0.75 mm.; thickness 0.45 mm.

Type specimen (U. S. N. M. Coll. No. 354033) from Aquia formation, Upper Marlboro, Maryland.

This is in some ways the handsomest species of the series,

especially in the ornamentation of the dorsal side. The figured specimen shows the last-formed chamber broken away, and the large resorbed lobe of the previous aperture.

It is represented in the Claiborne in the Lisbon formation, by the following variety:

LAMARCKINA MARYLANDICA Cushman, n. sp., var. CLAIBORNENSIS Cushman, n. var.

Variety differing from the typical in the greater involution of the dorsal side, and the greater development of the ornamentation so that the raised costae of the last-formed coil coalesce at the umbo or very near it.

Type of the variety (U. S. N. M. Coll. No. 354034) occurs in the Lisbon formation with *Lamarckina cristellaroides* (Terquem). Branch at bridge ½ mile N. E. of River Falls, Covington Co., Ala., collected by C. W. Cooke and Julia Gardner.

The variety evidently represents a slightly later and more highly developed form of the typical form of the species.

LAMARCKINA MARYLANDICA Cushman, n. sp., var. YEGUAENSIS Cushman, n. var.

Variety differing from the typical in the sutures, which are slightly limbate but depressed throughout where the typical form of the species has the sutures raised and confluent.

Cotypes of variety (Cushman Coll. No. 5131) from the Yegua formation of Texas, N. of Nixon, Gonzales Co., collected by Esther R. Applin.

LAMARCKINA CRISTELLAROIDES (Terquem)

Rotalina cristellaroides TERQUEM, Mém. Soc. géol. France, ser. 3, vol. 2, 1882, p. 57, pl. 3 (11), figs. 15 *a-c*.

Test small, longer than broad, the chambers rapidly increasing in thickness as added, 7 chambers in the last-formed coil, dorsal side strongly convex, smooth and finely perforate, the sutures distinct, flush with the surface, ventral side convex, umbilicate, smooth, and highly polished, the sutures slightly depressed; aperture large, broader than long.

Length 0.40 mm.

Terquem described this species from the Upper Eocene of the Paris Basin. I have in my own collection specimens from localities in the Upper Eocene of the Paris Basin, and they resemble very closely specimens which occur in the Gosport sand member of the Claiborne, Bluff at foot of Gopher Hill, Washington

Co., Ala., collected by T. Wayland Vaughan, and in the Lisbon, branch at bridge ½ mile N. E. of River Falls, Covington Co., Ala., collected by C. W. Cooke and Julia Gardner.

This species most nearly resembles *Lamarckina glabrata* Cushman, but is smaller, more elongate, the chambers piling up causing a thicker adult, and the dorsal surface is smooth.

LAMARCKINA OCALANA Cushman, n. sp.

Plate 1, figs. 4 *a-c*

Test subcircular in outline, periphery slightly lobulate, thin, slightly biconvex, periphery very thin, slightly keeled, composed of about 1½ coils, 7 chambers in the last-formed coil; dorsal side smooth and very finely perforate, the sutures barely depressed, not limbate; ventral side flattened or slightly convex, umbilicate, smooth and highly polished, sutures barely depressed; aperture large with a broadly rounded projecting lip.

Diameter about 1 mm.; thickness 0.35 mm.

Type specimen (U. S. N. M. Coll. No. 354032) from Ocala Limestone, near Blue Springs, Jackson Co., Fla., collected by C. W. Cooke and Julia Gardner.

This is the largest of the species of the genus, and may be distinguished by its smooth, unornamented dorsal surface, tendency to become keeled, and compressed form.

LAMARCKINA HALKYARDI Cushman, new name

Pulvinulina erinacea HALKYARD (not Karrer), Mem. Proc. Manchester Lit. Philos. Soc., vol. 62, pt. 2, 1918 (1919), p. 124, pl. 8, fig. 8.

Halkyard figures a species which belongs to this genus from the Eocene of Biarritz, France. It resembles in certain respects *Lamarckina rugulosa*, but differs from that species in the acute periphery as well as the slightly more rounded form. It resembles it, however, in the smooth character of the ventral surface, showing in the line of coiling on the dorsal surface. It is distinct from *Lamarckina erinacea* (Karrer) of the Miocene.

LAMARCKINA GLABRATA (Cushman)

Plate 1, figs. 6 *a-c*

Pulvinulina glabrata CUSHMAN, U. S. Geol. Survey, Prof. Paper 129, 1922, pp. 99, 138, pl. 22, figs. 6, 7; Prof. Paper 133, 1923, p. 45, pl. 6, figs. 11, 12.

Test biconvex, longer than broad, periphery somewhat lobulate; composed of 2 coils or less, 7 chambers in the last-formed

coil, dorsal side coarsely punctate or somewhat spinose; the sutures depressed, the earlier ones slightly limbate, ventral side strongly umbilicate, smooth and highly polished, the sutures barely depressed; aperture large with a projecting lip from the last-formed chamber.

Length about 0.50 mm.; thickness 0.22 mm.

This species is known from several stations in the Byram Marl and Mint Spring Marl members of the Lower Oligocene of Mississippi.

LAMARCKINA UMBILICATA (Heron-Allen and Earland)

Pulvinulina scabra H. B. Brady, var. *umbilicata* Heron-Allen and Earland, Journ. Roy. Micr. Soc., 1924, p. 179, pl. 14, figs. 111-113.

Heron-Allen and Earland described this species as a variety of *Pulvinulina scabra* Brady, and specimens were from the Miocene, "Filter Quarry," Victoria, Australia. The species shows a very interesting development of the genus, in which the smooth, polished character of the ventral side extends up onto the periphery, so that as each new chamber is added the smooth character is left showing along the suture lines, as well as along the periphery. The edge of the test is fimbriate, and the surface on the dorsal side between the sutures very coarsely spinose. This forms the most highly developed species of the genus in the character of its ornamentation.

LAMARCKINA ERINACEA (Karrer)

Pulvinulina erinacea Karrer, Sitz. Akad. Wiss. Wien, vol. 58, pt. 1, 1868, p. 187, pl. 5, fig. 6.

This species described by Karrer is the genotype of the genus *Lamarckina* Berthelin. It is common in the Miocene of the Banat region of Hungary.

LAMARCKINA VENTRICOSA (H. B. Brady)

Discorbina ventricosa H. B. Brady, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 654, pl. 91, figs. 7 *a-c*.

This species described by Brady in the *Challenger* report and known from the eastern Atlantic evidently belongs to this genus, and is related to such species as *Lamarckina erinacea* (Karrer) and *L. halkyardi* Cushman, new name.

LAMARCKINA SCABRA (H. B. Brady)

Pulvinulina oblonga WILLIAMSON, var. *scabra* H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 689, pl. 106, fig. 8.

This species which was referred to by Brady as a variety of *Pulvinulina oblonga* probably belongs to the genus *Lamarckina*. There are records for it off Bermuda and west of the Azores, 435 and 1,000 fathoms. The other records are three off the coast of New Guinea, 17-155 fathoms, and off the Philippines, 95 fathoms. There may be two species involved under this name, one possibly identical with *L. ventricosa*.

The following shows the distribution of the American species:

Lower Oligocene:
- Vicksburg ..... L. glabrata

Eocene:
- Jackson:
  - Ocala ..... L. ocalana
- Claiborne ..... L. cristellaroides
  - Yegua ..... L. marylandica, var. yeguaensis
  - Lisbon ..... L. marylandica, var. claibornensis
  - Aquia ..... L. marylandica
- Wilcox ..... L. wilcoxensis
- Midway ..... L. rugulosa

Cretaceous:
- Ripley ..... L. ripleyensis

EXPLANATION OF PLATE 1

FIGS. 1 *a–c*. *Eouvigerina americana* Cushman, n. sp. X 125.
a, front view; *b*, side view; *c*, apertural view.

FIGS. 2 *a–c*. *Eouvigerina gracilis* Cushman, n. sp. X 125.
a, front view; *b*, side view; *c*, apertural view.

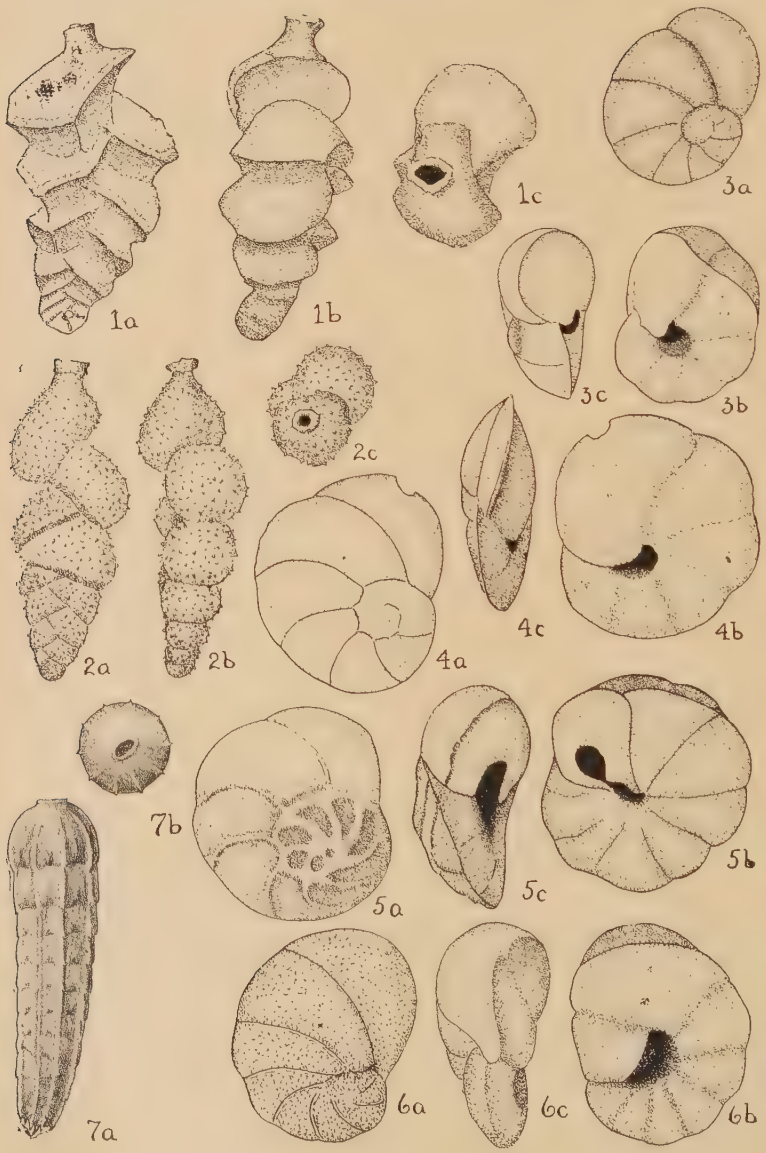
FIGS. 3 *a–c*. *Lamarckina wilcoxensis* Cushman, n. sp. X 65.
a, dorsal view; *b*, ventral view; *c*, peripheral view.

FIGS. 4 *a–c*. *Lamarckina ocalana* Cushman, n. sp. X 50.
a, dorsal view; *b*, ventral view; *c*, peripheral view.

FIGS. 5 *a–c*. *Lamarckina marylandica* Cushman, n. sp. X 65.
a, dorsal view; *b*, ventral view; *c*, peripheral view.

FIGS. 6 *a–c*. *Lamarckina glabrata* (Cushman). X 65.
a, dorsal view; *b*, ventral view; *c*, peripheral view.

FIGS. 7 *a, b*. *Siphogenerina plummeri* Cushman. X 65.
a, front view; *b*, apertural view.


1a
1b
1c
3a
3c
3b
2c
2a
2b
4a
4c
4b
7b
5a
5c
5b
7a
6a
6c
6b

25. SIPHOGENERINA PLUMMERI, A SPECIES FROM THE UPPER CRETACEOUS OF TEXAS

By JOSEPH A. CUSHMAN

Specimens which can be referred to *Siphogenerina* from the Cretaceous are decidedly rare. It is very interesting, therefore, to find a very distinct though very small species from the Upper Cretaceous of Texas. This has the characters well developed, and occurs in considerable numbers. Specimens of the genus are known from the Lower Eocene onward in many formations, and are now found mainly in the western tropical Atlantic, and in the more shallow waters of the Indo-Pacific region. The genus was exceptionally well developed in the Miocene of our own Pacific coast as well as in Panama, Trinidad, Florida, and Maryland.

SIPHOGENERINA PLUMMERI Cushman
Plate 1, figs. 7 *a*, *b*

Siphogenerina plummeri CUSHMAN, Proc. U. S. Nat. Mus., vol. 67, 1926, p. 18.

Test small, elongate, 3½ to 4 times as long as broad, very slightly tapering, greatest width developed by the last-formed chamber, early chambers biserial, later ones which make the bulk of the test uniserial, circular in transverse section; chambers distinct, slightly inflated; sutures distinct and depressed, especially in the uniserial portion; surface ornamented by about 8 longitudinal costae, sharp, and the posterior angles tending to project slightly in almost spinose angles, the last-formed chambers tending to develop supplementary costae between the primary ones, initial end of the test spinose formed by the ends of the costae; aperture elliptical with a distinct lip and very short neck.

Length up to 0.65 mm.; diameter 0.25-0.30 mm.

Holotype (Cushman Coll. No. 5103), from the Upper Navarro, 10 feet below the Basal Midway Greensand, along Walker Creek about 1 mile west of the main highway, about 6½ miles north of Cameron, Milam County, Texas, collected by Helen J. Plummer, who kindly furnished the drawings and types.

The species also occurs in the Navarro from ½ mile south of Kemp, Kaufman County, Texas, collected by Mrs. Plummer.

26. SOME FORAMINIFERA FROM THE MENDEZ SHALE OF EASTERN MEXICO

By Joseph A. Cushman

The upper portion of the so-called Papagallos shales of the region about Tampico has in it many very characteristic foraminifera, some of which are very widely distributed in both the eastern and western hemispheres. Many of these species are very closely related to or identical with species from the Taylor Marl of the Upper Cretaceous of Texas. The fauna is a considerable one but only a few of the striking species are figured in this present paper. Certain of the species such as *Pseudotextularia varians* Rzehak, *P. acervulinoides* (Egger), *Bolivina incrassata* Reuss, *B. rhomboidea* Cushman, n. sp., and *Pulvinulina arca* Cushman, n. sp., are widely distributed in the upper portion of the Papagallos shales, which have been given the distinctive name of Mendez from the outcrop near the town of that name (Belt, Bull. Amer. Assoc. Petr. Geol., vol. 9, No. 1, 1925, p. 140). *Pulvinulina arca* is a long-lived species continuing through much of the section, but modified in places so that distinct varieties can be recognized. Only one of these is here noted. Both *Pseudotextularia* and *Guembelina* are genera which mark the upper portion of the Cretaceous both in Europe and America, and which at least in the American section so far as recorded have not been found above the top of the Cretaceous. They therefore are excellent horizon markers. *Ellipsopleurostomella pleurostomelloides* is identical with specimens described by Heron-Allen and Earland from the chalk flints of England, and still further serves to correlate this formation. There are numerous other species which are identical with species found in the Cretaceous of Europe, but these few will serve the purposes of correlation.

Genus **PSEUDOTEXTULARIA** Rzehak, 1836

PSEUDOTEXTULARIA VARIANS Rzehak

Plate 2, figs. 4 *a*, *b*

Pseudotextularia varians RZEHAK, Ann. k. k. Nathist. Hofmuseums, vol. 10, pt. 2, 1895, p. 217, pl. 7, figs. 1-3.
Guembelina fruticosa EGGER, Abhandl. kön. bay. Akad. Wiss. München, Cl. II, vol. 21, 1899, p. 35, pl. 14, figs. 8, 9.

Test large, in the early stages definitely textularian, alternating series of chambers on either side of an elongate axis after which isolated chambers are formed near the periphery, subglobular in form, resulting in a spiral series about the margin, the central area being somewhat depressed; sutures distinct except in the early portion; wall of the textularian chambers longitudinally costate, later ones irregularly punctate.

Length up to 1½ mm.; breadth about 1 mm.; thickness from 0.40-1 mm.

This is a very variable species, in certain forms apparently the textularian series is held throughout the life history, and the test may become much compressed, in others the globular chambers are developed very early so that they make up most of the test. The end view may be circular or as in the figured specimen elliptical, often specimens which are nearly circular in transverse section in the early stages become more or less compressed in later growth. This is a very characteristic species of the Mendez, and is also found in Europe in the Upper Cretaceous. It does not persist in the Tertiary, at least in America.

Figured specimen (Cushman Coll. No. 5082) from shales near Coco, Hacienda El Limon, San Luis Potosi, Mexico.

PSEUDOTEXTULARIA ACERVULINOIDES (Egger)

Plate 2, fig. 5

Guembelina acervulinoides EGGER, Abhandl. kön. bay. Akad. Wiss. München, Cl. II, vol. 21, 1899, p. 36, pl. 14, figs. 17, 18, 20-22.
Pseudotextularia acervulinoides CUSHMAN, Journ. Wash. Acad. Sci., vol. 15, No. 6, 1925, p. 134.

This species differs from *Pseudotextularia varians* Rzehak in the very greatly reduced textularian development, the isolated, globular chambers developing very early and forming a very much compressed test, which is several times as broad as thick, and in full grown specimens the breadth is greater than the length.

Length up to 0.75 mm.; breadth up to 0.90 mm.

This species originally described by Egger from the Upper Cretaceous of the Bavarian Alps is characteristic of the Mendez shale, and also of certain portions of the Taylor Marl of Texas.

Figured specimen (Cushman Coll. No. 5075) from near Guerrero, San Luis Potosi, Mexico.

Genus **ELLIPSOPLEUROSTOMELLA** Silvestri, 1903

ELLIPSOPLEUROSTOMELLA PLEUROSTOMELLOIDES (Heron-Allen and Earland)

Plate 2, fig. 6

Ellipsoidella pleurostomelloides Heron-Allen and Earland, Journ. Roy. Micr. Soc., 1910, p. 415, pl. 10, figs. 1-11; 1911, p. 317.

Test elongate, slightly tapering; chambers biserial, inflated, circular in transverse section; sutures slightly depressed, distinct; wall smooth; aperture terminal with an overhanging hoodlike projection, the aperture itself elongate.

Length 0.65 mm.; breadth 0.15 mm.

Figured specimen (Cushman Coll. No. 5087) from Tamuin River, S. E. of Guerrero, San Luis Potosi, Mexico.

This species, which occurs at a number of localities in the Mendez, seems to be identical with a species described from the Chalk of England.

Genus **PLEUROSTOMELLA** Reuss, 1860

PLEUROSTOMELLA TORTA Cushman, n. sp.

Plate 2, fig. 7

Test large, subcylindrical, composed of few chambers, sides nearly parallel, slightly lobate, circular in transverse section; chambers biserial throughout, the axis of the early portion somewhat twisted; sutures distinct, limbate, slightly depressed; wall smooth; aperture elliptical with a slight lip and a platelike tooth with a central indentation.

Maximum length 2.10 mm.; maximum breadth 0.65 mm.

Holotype (Cushman Coll. No. 5102) from east of Pujal, San Luis Potosi, Mexico.

This is one of the largest species of the genus, and is characterized by the distinctly limbate sutures, and in many of the specimens by the peculiar twisted axis of the early portion.

Genus **BOLIVINA** d'Orbigny, 1839

BOLIVINA INCRASSATA Reuss

Plate 2, figs. 1 *a*, *b*

Bolivina incrassata REUSS, Haidinger's Nat. Abh. 4, pt. 1, 1851, p. 45, pl. 4, fig. 13.

Test stout, about 2½ to 3 times as long as broad; chambers fairly numerous, distinct, only slightly inflated; sutures distinct, oblique, slightly depressed; periphery rounded, whole test gently tapering, greatest width toward the apertural end; wall thick, smooth, finely punctate; aperture elongate oval with a very slight lip.

Length up to 1.25 mm.; breadth up to 0.45 mm.; thickness 0.30 mm.

Figured specimen (Cushman Coll. No. 5069) from near Coco, Hacienda El Limon, San Luis Potosi, Mexico.

Reuss originally described this species from the Upper Cretaceous of Europe where it is recorded by many authors.

BOLIVINA INCRASSATA Reuss, var. **LIMONENSIS** Cushman, n. var.

Plate 2, fig. 2

Test differing from the typical in the much longer, more slender form.

Length up to 1.65 mm.; breadth 0.30 mm.; thickness 0.20 mm.

Holotype of variety (Cushman Coll. No. 5068) from near Guerrero, San Luis Potosi, Mexico.

At first it was thought that this might be the microspheric form of *Bolivina incrassata*, but both forms have been found of that species developing the same adult test. The general appearance, the surface, and the obliquity of the sutures of the variety are very close to the typical, but it is much longer and more slender, and can be distinguished at once from the typical form of this species.

BOLIVINA RHOMBOIDEA Cushman, n. sp.

Plate 2, figs. 3 *a*, *b*

Test rhomboid both in front and end views, in front view breadth only slightly less than the length, and the greatest width being an oblique line in almost all specimens, periphery subacute, the apertural end somewhat rounded, initial portion much compressed, rather rapidly increasing in thickness toward

the apertural end; chambers obscured by the surface ornamentation which consists of two nearly parallel median costae, from which oblique costae branch toward the periphery, these again may be connected by short, transverse costae, all ending at the periphery in a raised, smooth surface; aperture elongate, slightly oblique with a trace of a raised lip.

Length 0.50 mm.; breadth 0.40 mm.; thickness 0.20 mm.

Holotype (Cushman Coll. No. 5039) from 5 kilometers S. E. of Guerrero, on the Tamuin River, San Luis Potosi, Mexico.

This is a very distinctly ornamented species, reminding one very slightly of *Bolivina draco* Marsson, which is recorded from the Upper Cretaceous of Europe. This is, however, very distinct in its ornamentation.

Genus GUEMBELINA Egger, 1899
GUEMBELINA EXCOLATA Cushman, n. sp.

Plate 2, fig. 9

Test small, much compressed, broadest near the apertural end, initial end pointed, early portion with the chambers arranged as in *Virgulina*, later chambers biserial; chambers fairly distinct, slightly inflated, increasing in height as added; sutures slightly depressed; wall ornamented with curved, slightly oblique, longitudinal costae, those of separate chambers usually distinct from those of adjacent chambers except in the early portion where the costae may cover more than one chamber; aperture elongate oval.

Length 0.45 mm.; breadth 0.30 mm.; thickness 0.18 mm.

Holotype (Cushman Coll. No. 5071) from the east bank of the Tamuin River, 5 kilometers southeast of Guerrero, San Luis Potosi, Mexico.

This curiously ornamented species of very small size is nevertheless distinct and often occurs in considerable numbers. It is allied with some of the species described from Europe from the Upper Cretaceous, but seems to be distinct from any of these.

Genus NODOSARIA Lamarck, 1812
NODOSARIA OBSCURA Reuss

Plate 2, fig. 8

Nodosaria obscura Reuss, Verstein. Böhm. Kreide, 1845-46, pt. 1, p. 26, pl. 13, figs. 7-9.

Test fusiform, circular in transverse section, composed of comparatively few chambers ornamented with 10-12 prominent

longitudinal costae; sutures between the chambers visible between the costae; apertural end somewhat projecting.

Length 0.75 mm.

Figured specimen (Cushman Coll. No. 5073) from the south side of Rancho Nuevo, S. W. of Guerrero, San Luis Potosi, Mexico.

The smallest specimens of this species very much resemble costate forms of *Lagena*, but in the larger ones the sutures become more prominent. The species is known from numerous records from the Upper Cretaceous of Europe.

Genus FRONDICULARIA Defrance, 1824
FRONDICULARIA ARCHIACIANA d'Orbigny

Plate 3, fig. 4

Frondicularia archiaciana D'ORBIGNY, Mém. Soc. Géol. France, vol. 4, 1840, p. 20, pl. 1, figs. 34-36.

Test elongate, sides nearly parallel and truncate, the broader faces nearly parallel, much flattened, composed of few chambers well marked by the raised, limbate sutures which may have between them and on the first-formed chamber additional secondary costae, initial end pointed.

Length 1.25 mm.; breadth 0.35 mm.

Figured specimen (Cushman Coll. No. 5105) from near Huiches, Hacienda El Limon, San Luis Potosi, Mexico.

d'Orbigny originally described this species from the Upper Cretaceous of France, and it has occurred from the records rather widely in this formation of Europe. The original of the species had the area between the raised sutures smooth, but nearly all of the specimens from the Mexican material have the early chamber particularly, with definite costae.

FRONDICULARIA BAUDOUINIANA (d'Orbigny)

Plate 3, fig. 5

Flabellina baudouiniana D'ORBIGNY, Mém. Soc. Géol. France, ser. 1, vol. 4, 1860, p. 24, pl. 2, figs. 8-11.

Test flattened, oval, initial end broadly rounded, apertural end somewhat pointed, composed of few chambers, the early ones coiled; sutures limbate, raised above the general surface as sharp costae; wall between smooth.

Length 0.85 mm.; breadth 0.45 mm.; thickness 0.23 mm.

Figured specimen (Cushman Coll. No. 5116) from near Las Palmas, Hacienda El Limon, San Luis Potosi, Mexico.

This is the form that has been referred by numerous writers to this species of d'Orbigny, which was described from the Upper Cretaceous of France. It is recorded from the Cretaceous of Central Europe and of England.

Genus TRUNCATULINA d'Orbigny, 1826
TRUNCATULINA SPINEA Cushman, n. sp.

Plate 2, figs. 10 *a-c*

Test small, planoconvex, the dorsal side flat or often slightly concave, ventral side very strongly convex, periphery acute, marked by a series of spines, one for each chamber, either simple or with secondary small spinose projections at the base, about 7 chambers in the last-formed coil, indistinct; sutures indistinct except on the ventral side where they may be slightly depressed; aperture ventral, elongate.

Diameter 0.35 mm.; thickness 0.18 mm.

Holotype (Cushman Coll. No. 5083) from shale on the Guerrero-Taninul Road, San Luis Potosi, Mexico.

This is a very small species but is very distinct in its characters, and has a wide distribution in the Mexican Mendez shales, although the vertical distribution seems not to be great.

TRUNCATULINA EXCOLATA Cushman, n. sp.

Plate 3, figs. 2 *a, b*

Test planoconvex, dorsal side flattened, vertical side broadly convex, periphery angled, dorsal side curiously ornamented with irregular costae along the suture lines but variously twisted, the intermediate area often roughened, the ventral side smooth, 9 or 10 chambers in the last-formed coil; sutures on the ventral side indistinct; aperture elongate at the base of the last-formed chamber on the ventral side.

Diameter 0.50 mm.; thickness 0.25 mm.

Holotype (Cushman Coll. No. 5104) from shale along the railroad near Coco, Hacienda El Limon, San Luis Potosi, Mexico.

This is a curiously ornamented species and like *Truncatulina spinea* Cushman has a wide geographic range, but comparatively short vertical range. It seems to show very little variation in the material examined although specimens were numerous.

Genus PULVINULINA Parker and Jones, 1862
PULVINULINA ARCA Cushman, n. sp.

Plate 3, figs. 1 *a-c*

Test biconvex, the periphery truncate, about 7 chambers in the last-formed coil; chambers very distinct; sutures both on the dorsal and ventral sides limbate, on the dorsal side curved, raised above the general surface in a distinctly beaded ornamentation, fusing with the raised periphery, the early sutures often more beaded than later ones, on the ventral side the chambers of the last-formed coil do not extend in to the center, leaving a distinct umbilical area; aperture elongate on the ventral side at the base of the last-formed chamber.

Diameter usually less than 1 mm.

Holotype (Cushman Coll. No. 5078) from near Huiches, Hacienda El Limon, San Luis Potosi, Mexico.

This is the most abundant of all the species of the so-called Papagallos series in the Upper Cretaceous of the Tampico region. It has a very broad distribution both geographically and vertically, in the Upper Cretaceous series. Through its wide vertical distribution, it shows several varietal forms, some of which may be more easily distinguished than others. In one of these the entire test becomes much flattened and the truncate character of the periphery is much more marked than in the typical form. In another the periphery is developed into distinct angles. Of the various varieties *Pulvinulina arca* Cushman, n. sp., var *contusa* Cushman, n. var. is perhaps the most distinctive.

PULVINULINA ARCA Cushman, n. sp., var. CONTUSA Cushman, n. var.

Variety differing from the typical in the greater size, much greater elevation of the spire on the dorsal side, and particularly striking the concave appearance of the chambers on the dorsal side, those of one coil coming in line with preceding ones so that the entire test develops something of a pyramidal form.

Holotype of variety (Cushman Coll. No. 5079) from near Coco, Hacienda El Limon, San Luis Potosi, Mexico.

This variety has much the appearance of a conical, soft hat, in which there are made dents running from the apex to the border. This variety is often very abundant in certain horizons replacing to a large measure the typical form.

Genus **CORNUSPIRA** Schultze, 1854
CORNUSPIRA CRETACEA Reuss

Plate 3, fig. 3

Cornuspira cretacea Reuss, Sitz. Akad. Wiss. Wien, vol. 40, 1860, p. 177, pl. 1, figs. 1 *a*, *b*.

There are specimens which occur in the Mendez shales, which agree very closely with the figure and description of this species as described and figured by Reuss from the Upper Cretaceous of Europe. Specimens are very apt to be somewhat contorted possibly due to conditions of preservation.

EXPLANATION OF PLATE 2

FIGS. 1 *a*, *b*. *Bolivina incrassata* Reuss. X 45.
a, front view; *b*, apertural view.

FIG. 2. *Bolivina incrassata* Reuss, var. *limonensis* Cushman, n. var. X 45.

FIGS. 3 *a*, *b*. *Bolivina rhomboidea* Cushman, n. sp. X 45.
a, front view; *b*, apertural view.

FIGS. 4 *a*, *b*. *Pseudotextularia varians* Rzehak. X 50.
a, front view; *b*, end view.

FIG. 5. *Pseudotextularia acervulinoides* (Egger). X 50.

FIG. 6. *Ellipsopleurostomella pleurostomelloides* (Heron-Allen and Earland). X 50.

FIG. 7. *Pleurostomella torta* Cushman, n. sp. X 35.

FIG. 8. *Nodosaria obscura* Reuss. X 45.

FIG. 9. *Guembelina excolata* Cushman, n. sp. X 65.

FIGS. 10 *a–c*. *Truncatulina spinea* Cushman, n. sp. X 100.
a, ventral view; *b*, dorsal view; *c*, side view.

EXPLANATION OF PLATE 3

FIGS. 1 *a–c*. *Pulvinulina arca* Cushman, n. sp. X 65.
a, dorsal view; *b*, ventral view; *c*, peripheral view.

FIGS. 2 *a*, *b*. *Truncatulina excolata* Cushman, n. sp. X 65.
a, dorsal view; *b*, peripheral view.

FIG. 3. *Cornuspira cretacea* Reuss. X 50.

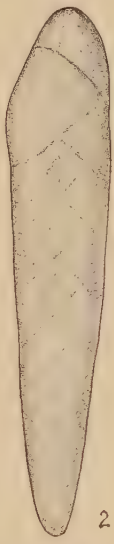
FIG. 4. *Frondicularia archiaciana* d'Orbigny. X 45.

FIG. 5. *Frondicularia baudouiniana* (d'Orbigny). X 65.

FIGS. 6 *a–c*. *Lamarckina rugulosa* Plummer, MS. X 65.
a, dorsal view; *b*, peripheral view; *c*, ventral view.


1b


1a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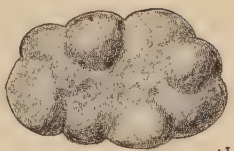
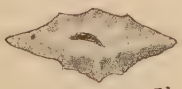

4b


4a


6


5


3b


8


7


3a

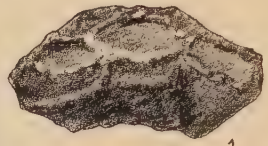

9


10c

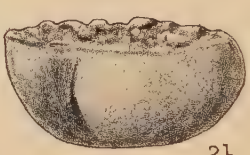

10a


10b


1a


1c


1b


2b


2a


3


4


5


6a


6b


6c

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the foraminifera that have come to hand.

Yabe, H. and Hanzawa, S.

A Lepidocyclina-Limestone from Klias Peninsula, B. N. Borneo.

(Verhandl. Geol.-Mijn. Gen. Ned. Kol. Geol. Ser., vol. 8, 1925, pp. 617-632, pls. 1-4, 4 text figs.) *The Hague.*

A number of species and varieties of *Spiroclypeus* and *Lepidocyclina* are fully described and well illustrated by photographs of exteriors and sections as well as a few text figures. One new variety is described.

Yabe, H. and Hanzawa, S.

A Lepidocyclina-Limestone from Sangkoelirang, D. E. Borneo.

(Japanese Journ. Geol. Geog., vol. 3, 1924, pp. 71-76, pls. 9-12, 1 text fig.) *Tokyo.*

The several species from this limestone are illustrated by excellent plates from photographs of thin sections. Species of *Lepidocyclina, Miogypsina* and *Cycloclypeus* are included and described in detail.

Ellisor, A. C.

The Age and Correlation of the Chalk at White Cliffs, Arkansas, with Notes on the Subsurface Correlations of Northeast Texas.

(Bull. Amer. Assoc. Petr. Geol., vol. 9, 1925, pp. 1152-1164, pls. 20, 21.) *Chicago.*

Several lists of foraminifera are given from Texas localities. The plates give map and well sections.

Cushman, J. A.

Recent Foraminifera from Porto Rico.

(Publ. 344, Carnegie Inst. Washington, Feb. 1926, pp. 73-84, pl. 1.) *Washington.*

This paper records the results of a study of the shallow water foraminifera of several bottom samples especially from San Juan Harbor and comparison with other West Indian areas.

Cushman, J. A.

Foraminifera of the genera Siphogenerina and Pavonina.

(Proc. U. S. Nat. Mus., vol. 67, 1926, pp. 1-24, pls. 1-6.) *Washington.*

This paper brings together what is known in regard to the species, both recent and fossil, of these two genera, with figures of most of the species except those already published in these Contributions.

Cushman, J. A. and Applin, E. R.

Texas Jackson Foraminifera.

(Bull. Amer. Assoc. Petr. Geol., vol. 10, 1926, pp. 154-189, pls. 5-10.) *Chicago.*

The species of the Upper Eocene (Jackson) of Texas as they are found in surface outcrops and well samples are described and figured. Many of these are closely related to species which occur in the Jackson of the other portions of the Gulf Coastal Plain and in the Alazan of Mexico.

J. A. C.

CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

VOL. 2, PART 2, JULY, 1926

27. SOME NEW FORAMINIFERA FROM THE UPPER EOCENE OF THE SOUTHEASTERN COASTAL PLAIN OF THE UNITED STATES

By Joseph A. Cushman

In the course of several years' work on the faunas of the Coastal Plain region of the United States, many new species of foraminifera have been found. Some of these have already been described, and a number of others are included in this present paper. Some of these show distinct relationships with other regions, and have helped to show very conclusively that the species of the Upper Eocene are in many instances very close to species now living off the coast in this same region. The Eocene species in many cases are undoubtedly the ancestral forms of these recent ones. There is a very considerable difference in the faunas of this Upper Eocene in the shallow-water type characterized by the Ocala limestone of Florida, and the deeper-water sediments such as found in parts of Mississippi and Alabama. The connection between the Upper Eocene of the Gulf Coastal Plain especially with that of the Alazan of Mexico is also marked.

Descriptions of the species follow:

TEXTULARIA ADALTA Cushman, n. sp.
Plate 4, figs. 2 *a*, *b*

Test elongate, slender, early portion tapering and compressed, adult portion thicker and with the sides nearly parallel, periphery subacute except in the last few chambers which are rounded; chambers numerous, the last 5 or 6 making up half the test, earlier ones indistinct, low and broad, later ones more inflated, higher; sutures distinct especially in the later portion where they are somewhat depressed, usually oblique; wall finely arenaceous, only slightly roughened; aperture a high, arched opening in the central part of the base of the apertural face.

Maximum length 2 mm.

Type specimen (U. S. N. M. Coll. No. 354111) from 3½ miles N. E. of Brooklyn, Conecuh Co., Alabama.

TEXTULARIA OCALANA Cushman, n. sp.

Plate 4, figs. 3 *a, b*

Test very much compressed, sides nearly flat, apical end bluntly pointed, apertural end broadly rounded, periphery even, subacute; chambers few, low and broad, not inflated; sutures very slightly depressed, rather indistinct; wall finely arenaceous, smoothly finished.

Maximum length 0.70 mm.

Type specimen (U. S. N. M. Coll. No. 354112) from Ocala limestone, 1¼ miles S. of Newberry, Alachua Co., Florida.

This peculiarly shaped species is very rare, occurring only in the typical Ocala limestone at a few stations. Its very broad form with the sides very much compressed, and but very slightly convex, will distinguish this species from any other of the Vicksburg or Jackson species. It probably occurs at more stations, but the finer material of this phase of the Ocala is often not well preserved.

BOLIVINA ATTENUATA Cushman, n. sp.

Plate 4, fig. 4

Test very strongly compressed, broad, rapidly increasing in width with newly added chambers, in the type specimen about as broad as long, central portion slightly thickened; chambers comparatively few, distinct, elongate, curved backward strongly, the inner end of each with a slight backwardly pointing projection; sutures very distinct, limbate, the periphery of the chamber with a slight keel continuous with the sutures; earliest chambers with a reticulate ornamentation, later ones smooth.

Length 0.40 mm.

Type specimen (U. S. N. M. Coll. No. 354121) from 1½ miles S. W. of Perdue Hill, Monroe Co., Alabama.

This species has a very broad test, much broader than any of the others of the Upper Eocene except perhaps *Bolivina frondea* Cushman, which it resembles in no other particular. The early ornamentation is suggestive of *B. caelata* Cushman, and the later portion with its peculiar backwardly projecting inner portion of the chamber is somewhat like *B. jacksonensis* Cushman.

BOLIVINA SPIRALIS Cushman, n. sp.

Plate 4, figs. 6 *a*, *b*

Test small, only slightly compressed, spirally twisted, periphery rounded; chambers numerous, distinct, last 5 chambers making up half the test; sutures strongly depressed, distinct; wall in the earlier chambers roughened and slightly spinose, later ones coarsely punctate.

Length 0.50 mm.

Type specimen (U. S. N. M. Coll. No. 354120) from Ingleside marl pit, Charleston, South Carolina.

This species in some respects resembles the recent Indo-Pacific *Bolivina tortuosa* H. B. Brady, but is much less compressed and has a roughened exterior, almost spinose in the young.

BOLIVINA GARDNERAE Cushman, n. sp.

Plate 4, figs. 7 *a*, *b*

Test elongate, compressed, slightly tapering from the rounded initial end, periphery rounded, test broadly oval in transverse section, sides nearly parallel; chambers numerous, slightly inflated, distinct; sutures distinct, depressed; wall coarsely perforate, without a definite arrangement of the perforations; aperture elongate.

Maximum length 0.40 mm.

Type specimen (U. S. N. M. Coll. No. 354119) from 5 miles N. of Millen, Jenkins Co., Georgia.

This species also occurs in other localities in the Upper Eocene from South Carolina, Georgia and Alabama. It also occurs in the Lower Vicksburg. It is more compressed, shorter, and broader than the related *Bolivina gracilis*, and the perforations have no definite arrangement.

BIFARINA DALLI Cushman, n. sp.

Plate 4, figs. 5 *a*, *b*

Test slightly compressed, elongate, slightly tapering from the rounded initial end, apertural end truncate; chambers few, distinct, inflated especially toward the apertural end; sutures distinct, compressed; wall ornamented with numerous fine but sharp costae on the earlier two-thirds, the last-formed chambers smooth, finely punctate; aperture becoming terminal in the adult, elliptical or elongate oval.

Maximum length 0.55 mm.

Type specimen (U. S. N. M. Coll. No. 354118) from ½ mile S. E. of Melvin, Choctaw Co., Alabama.

This is a beautifully ornamented species. The later chambers in adults show it to be *Bifarina* in having the aperture terminal and the chamber occupying the entire width of the test. The species is named in honor of Dr. W. H. Dall, of the United States National Museum.

BULIMINELLA ALABAMENSIS Cushman, n. sp.

Plate 4, figs. 8 *a*, *b*

Test small, ovate, broadest in front view slightly above the middle, initial end pointed, apertural end broadly rounded, somewhat obliquely truncated, whole test of 1½ to 2 coils; chambers fairly distinct, not inflated; sutures distinct but not depressed; apertural face with a very large open area somewhat broadening toward the base which reaches to at least the middle of the test; wall very thin and transparent.

Length 0.22 mm.

Type specimen (U. S. N. M. Coll. No. 354123) from ¼ mile W. of Water Valley, Choctaw Co., Alabama.

This species differs from others of the genus in the peculiar large open area on the apertural side of the test, broadening toward the base which reaches to or below the middle line of the test. The apical end is acute. It is very distinct from the species recorded from the Lower Oligocene.

VULVULINA ADVENA Cushman, n. sp.

Plate 4, figs. 9 *a*, *b*

Test small, thin, much compressed, periphery acute but not keeled, early chambers alternating, later ones (as many as 5) uniserial; chambers rather high, gently sloping; sutures of the biserial portion flush with the surface, the whole early portion smooth, in the later portion the sutures slightly depressed; wall smoothly finished, each angle of the chambers with a short, spinose projection, even those of the uniserial portion; aperture elongate, terminal.

Length up to 1.25 mm.

Type specimen (U. S. N. M. Coll. No. 354134) from 3½ miles S. E. of Cullomburg, Alabama.

This is a very distinct species having a very white test, smooth, and shining, the material being very fine grained.

GAUDRYINA JACKSONENSIS Cushman, n. sp.

Plate 5, figs. 1 *a*, *b*

Test large, elongate, irregularly triangular in section, triserial portion short, biserial portion angular, angles subacute, almost carinate; chambers distinct, very slightly inflated; sutures distinct, slightly depressed; wall composed of fine sand grains with a large amount of cement, surface smoothly finished; aperture semi-circular, in a re-entrant at the base of the apertural face of the last-formed chamber.

Maximum length 2 mm.

Type specimen (U. S. N. M. Coll. No. 354115) from Ingleside marl pit, Charleston, South Carolina.

This species also occurs in the Upper Eocene of Alabama and Mississippi, as well as in the Alazan clay of Mexico.

This is a striking species of the deeper water sediments of the Upper Eocene. It is apparently the direct ancestral form of the recent species, *Gaudryina atlantica* (Bailey), which is very abundant off the eastern coast of the United States. It is a dominant species in the *Albatross* dredgings at depths ranging from 67 to 210 fathoms. The recent species has carried the development further in the loss of the angles in the last-formed chambers, the greater sharpness of the angles of earlier chambers, and the reduction of the early triserial stage. *G. atlantica* is also a larger species.

GAUDRYINA GARDNERAE Cushman, n. sp.

Plate 5, figs. 2 *a*, *b*

Test elongate, early portion triserial and forming a distinctly triangular test in section, the angles somewhat rounded, sides flattened or very slightly convex, later portion biserial, with straight, nearly parallel sides, somewhat polygonal in section; chambers rather indistinct, especially in the earlier portion, in the later portion more distinct and the sutures somewhat depressed; wall rather coarsely arenaceous; aperture rounded, deep, at the inner border of the last-formed chamber.

Length 0.85 mm.

Type specimen (U. S. N. M. Coll. No. 354114) from 1½ miles S. W. of Perdue Hill, Monroe Co., Alabama.

This resembles *Gaudryina triangularis* Cushman in some respects, and the Lower Oligocene specimens referred to that species may belong here.

VERNEUILINA SCULPTILIS Cushman, n. sp.

Plate 5, fig. 3

Test somewhat longer than broad, pyramidal, three sided, widest at about two-thirds its length, triangular in transverse section, sides flattened or even slightly convex, apical end tapering, in well preserved specimens ending in a short point, angles of the test acute; wall sculptured, the sutural lines strongly raised, the central line of each side of the test marked by a strongly raised costa; aperture on the inner border of the last-formed chamber.

Maximum length 0.50 mm.

Type specimen (U. S. N. M. Coll. No. 354117) from W. bank Pea River, Geneva Co., Alabama.

This is a beautifully sculptured species. The apical end is prolonged into a short spine.

VALVULINA OCALANA Cushman, n. sp.

Plate 5, figs. 4 *a*, *b*

Test elongate, early portion triangular in section, the chambers closely set, later and larger portions loosely coiled; chambers numerous, those of the early triserial portion indistinct, later portion with the chambers inflated and very distinct; sutures indistinct in the early portion, depressed and distinct in the later portion; wall arenaceous but smoothly finished when the specimens are well preserved; aperture rounded, in a deep re-entrant of the apertural face, with an inwardly projecting toothlike plate above the opening.

Maximum length 1.5 mm.

Type specimen (U. S. N. M. Coll. No. 354113) from 2 miles S. E. of Ocala, Marion Co., Florida.

Valvulina ocalana is a very characteristic species of the shallow-water phase of the Upper Eocene especially of warm waters as developed in the Ocala limestone of Florida. Such deposits are not usually very well preserved as to their smaller fossils, but *V. ocalana* is a well characterized species recognizable even when the preservation would make impossible the specific identification of many other species. It is related to such species as *V. triangularis* d'Orbigny of the Eocene of the Paris Basin.

Valvulina ocalana is the direct ancestral form of a species now very abundant in shallow warm waters of coral reef conditions in the general West Indian region where it occurs in very

shallow water reefs of southern Florida, the Bahamas, Jamaica, etc. The recent species, *V. oviedoiana* d'Orbigny is a shorter, stouter form but with the same characteristic apertural features.

BULIMINA JACKSONENSIS Cushman, var. CUNEATA Cushman, n. var.

Variety differing from the typical in the larger number of costae (10 to 12), the more tapering form, and especially the very serrate character of the edge of the costae.

Length 1 mm.

Type specimen (U. S. N. M. Coll. No. 354122) from ½ mile S. E. of Melvin, Choctaw Co., Alabama.

This variety which is distinct from the typical form has been found at but one station, but occurs abundantly there.

POLYMORPHINA JACKSONENSIS Cushman, n. sp.

Plate 5, figs. 5 *a*, *b*

Test fairly large for the genus, broad and compressed, periphery broadly rounded, base rounded, apertural end narrowed to a slightly produced, broad, truncate end; chambers distinct, slightly inflated, elongate, unequally placed with reference to the vertical axis; sutures very slightly depressed, distinct; wall smooth; aperture radiate.

Maximum length 1.5 mm.

Type specimen (U. S. N. M. Coll. No. 354132) from near Blue Springs, Jackson Co., Florida.

The species is a characteristic one from the Upper Jackson, and I have specimens from North and South Carolina, Florida, Alabama, and Mississippi.

There are numerous species which this resembles in general characters, but none of them are sufficiently close so that this species from the Upper Eocene can be referred to them. This somewhat resembles *Polymorphina humboldti* Bornemann, as well as some of the species recorded from the Tertiary of the Australian region.

POLYMORPHINA JACKSONENSIS Cushman, n. sp., var. COSTIFERA Cushman, n. var.

Variety differing from the typical in the ornamentation of the test, which in the variety has numerous rounded, longitudinal costae on the basal portion of the test, sometimes covering a large portion of the surface. As a rule the variety and the

typical form do not occur together, although both occur at Jackson, Mississippi, and a very few other stations.

Type specimen (U. S. N. M. Coll. No. 354133) from 1 mile E. of Beck, Covington Co., Alabama.

EXPLANATION OF PLATE 4

FIGS. 1 *a–c.* *Lamarckina marylandica* Cushman, var. *yeguaensis* Cushman, n. var. X 65.
a, dorsal view; *b*, peripheral view; *c*, ventral view.
(See Vol. 2, pt. 1, p. 10.)

FIGS. 2 *a, b.* *Textularia adalta* Cushman, n. sp. X 65.
a, front view; *b*, apertural view.

FIGS. 3 *a, b.* *Textularia ocalana* Cushman, n. sp. X 65.
a, front view; *b*, apertural view.

FIG. 4. *Bolivina attenuata* Cushman, n. sp. X 65.
Front view.

FIGS. 5 *a, b.* *Bifarina dalli* Cushman, n. sp. X 65.
a, front view; *b*, apertural view.

FIGS. 6 *a, b.* *Bolivina spiralis* Cushman, n. sp. X 65.
a, front view; *b*, apertural view.

FIGS. 7 *a, b.* *Bolivina gardnerae* Cushman, n. sp. X 65.
a, front view; *b*, apertural view.

FIGS. 8 *a, b.* *Buliminella alabamensis* Cushman, n. sp. X 100.
a, side view; *b*, apertural view.

FIGS. 9 *a, b.* *Vulvulina advena* Cushman, n. sp. X 65.
a, side view; *b*, apertural view.

EXPLANATION OF PLATE 5

FIGS. 1 *a, b.* *Gaudryina jacksonensis* Cushman, n. sp. X 50.
a, front view; *b*, apertural view.

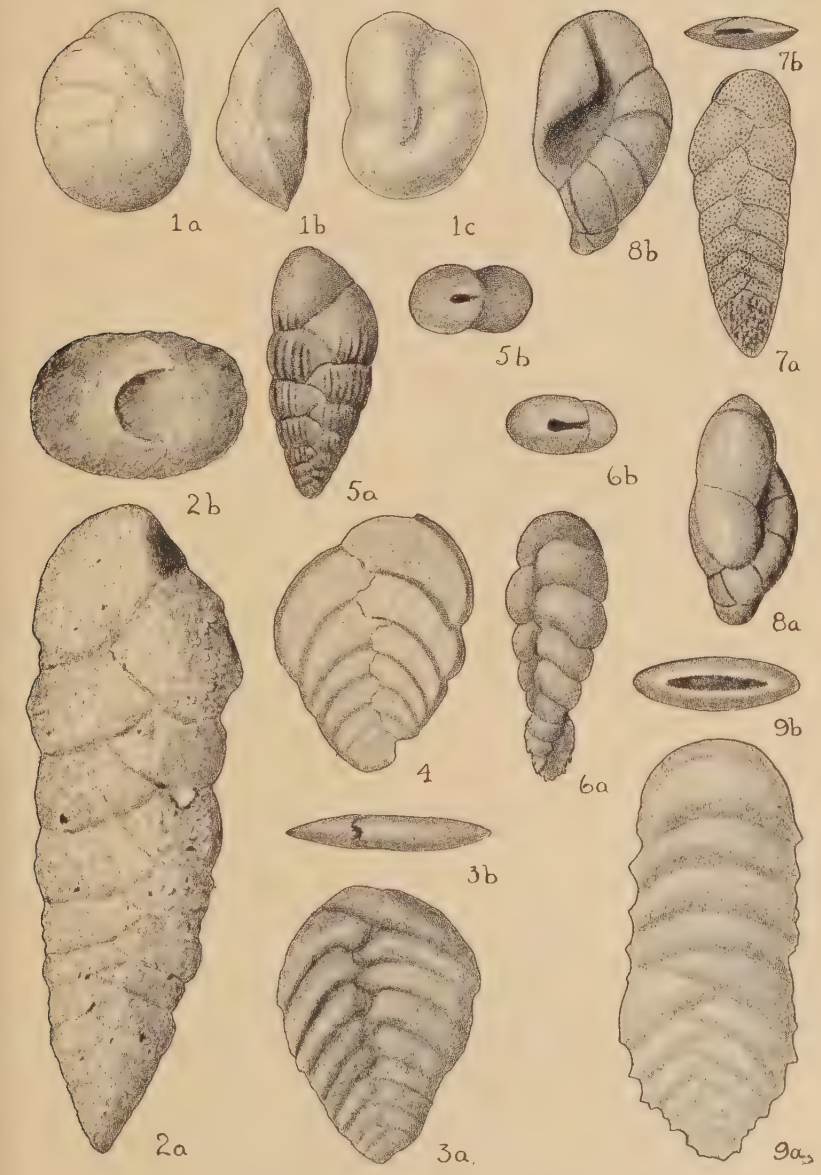
FIGS. 2 *a, b.* *Gaudryina gardnerae* Cushman, n. sp. X 65.
a, front view; *b*, apertural view.

FIG. 3. *Verneuilina sculptilis* Cushman, n. sp. X 65.

FIGS. 4 *a, b.* *Valvulina ocalana* Cushman, n. sp. X 65.
a, front view; *b*, apertural view.

FIGS. 5 *a, b.* *Polymorphina jacksonensis* Cushman, n. sp. X 50.
a, front view; *b*, side view.

FIGS. 6 *a–c.* *Lamarckina ripleyensis* Cushman. X 65.
a, dorsal view; *b*, ventral view; *c*, peripheral view.
(See Vol. 2, pt. 1, p. 8.)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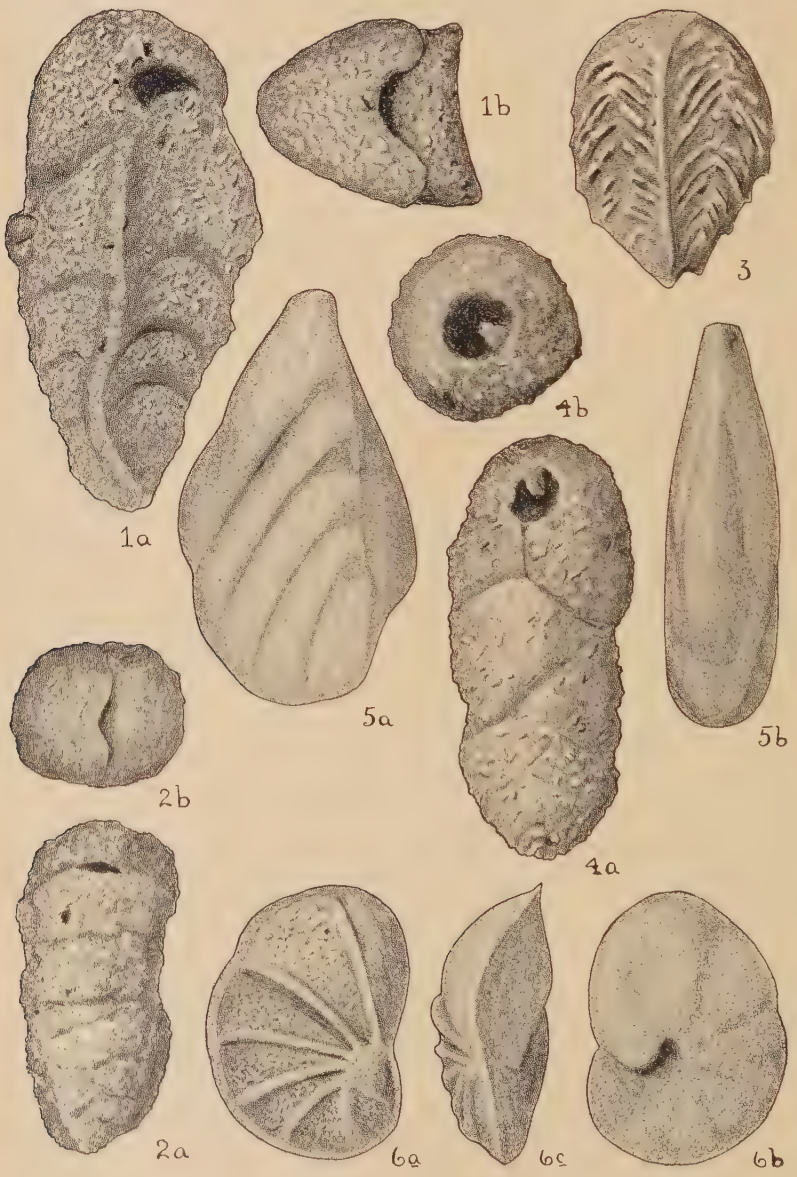
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28. A NEW PLECTOFRONDICULARIA FROM THE PLIOCENE OF CALIFORNIA

By JOSEPH A. CUSHMAN and ROSCOE E. STEWART

In the Pliocene of California there is a species of *Plectofrondicularia* already referred to in Volume 1, Part 4, page 89. A further study of this species shows that it is new. Specimens with the apertural end perfectly preserved must be very rare as in all specimens seen the final chamber is broken away.

PLECTOFRONDICULARIA CALIFORNICA Cushman and Stewart, n. sp.
Plate 6, figs. 9-11

Test somewhat compressed, very elongate, narrow, usually bilaterally symmetrical, occasionally asymmetrical due to a slight curvature of the early portion, the broad faces concave, sides diverging uniformly from the initial end which is rounded, more in the megalospheric and less in the microspheric form, the greatest breadth of the test being made by the last-formed chamber, the peripheral portion with 3 sharp platelike carinae, one in the middle line, the other two lateral; chambers numerous, early ones biserial, later ones uniserial, low, 2 to 3 times as wide as high, increasing very slightly in relative height toward the apertural end; sutures slightly limbate, later ones very slightly depressed; wall smooth, with a short central costa on the earlier portion.

Length 1.50 mm.; breadth .35 mm.; thickness .15 mm.

Holotype (Cushman Coll. No. 5562) from 3,260 feet, Torrance No. 7, Chanslor-Canfield Midway Oil Co., California.

In the Tertiary of America this genus is known from the Claiborne where there are very slender specimens referred to *Plectofrondicularia mexicana* (Cushman). This is biserial in the young. The Claiborne form is slightly more slender than the Mexican or Trinidad specimens, and there is more of a tendency to taper toward the apertural end. The last-formed chambers in the Claiborne form are also somewhat higher. These Claiborne specimens are from Liberty County, Texas, collected by Esther R. Applin.

The California Pliocene species, instead of having the sides parallel, is uniformly tapering throughout. The chambers are all low in comparison with *P. mexicana*, and do not, as in that species, elongate to any amount in the adult, but tend to keep the same relative proportions throughout.

29. SOME PLIOCENE BOLIVINAS FROM CALIFORNIA

By Joseph A. Cushman

The Pliocene of California or at least that part of it represented by the marine Fernando series is rich in foraminifera. The genera *Bolivina* and *Uvigerina* are especially abundant. They show that at the time of deposition of this series of sediments a rapid evolution of form was going on in these two genera. There are many forms with a more or less definite vertical range which may be distinguished in a careful study of well samples, especially cores, or in the outcrop material of the thick sediments of the Fernando.

The species of *Bolivina* are of especial interest as they belong to species which in most cases are living today in identical or slightly modified form in the cooler waters of the eastern Pacific along the western coasts of North and South America. In 1839 d'Orbigny described species from the west coast of South America which appear in the Recent and late Tertiary collections of California, and the waters of adjacent regions. The fauna of the cold waters of our west coast is very different from that of other regions, and the foraminifera are no exception. *Bolivina plicata* recorded widely is not the same as that of d'Orbigny from the eastern Pacific, which in this particular region has a very definite geographical and geological distribution. The same is true of the other species noted here. A description of some of the more conspicuous forms follows:

BOLIVINA PLICATA d'Orbigny

Plate 6, figs. 1 *a*, *b*

Bolivina plicata d'Orbigny, Voy. Amér. Mérid., vol. 5, pt. 5, "Foraminifères," 1839, p. 62, pl. 8, figs. 8, 9.—Goës, Bull. Mus. Comp. Zoöl., vol. 29, 1896, p. 48.

Test small, thick, elongate, very slightly tapering, the periphery broadly rounded, initial end broadly rounded; chambers distinct, inflated; the sutures distinct, somewhat depressed, nearly straight across, horizontal when the test is placed with the aperture up; wall ornamented with 1 or 2 costae on each side, usually running the entire length of the test except for the last-formed chamber, the costae rounded at the surface and broad, the surface and sides very finely plicated with alternating

grooves and ridges somewhat oblique but nearly parallel to the costae themselves; wall finely perforate; aperture elongate, extending somewhat above the outline of the chamber due to the definite lip that is developed.

Length up to 0.50 mm.; breadth 0.15-0.20 mm.; thickness 0.08-0.10 mm.

d'Orbigny's type specimens were from the Pacific off Valparaiso, Chile, where he found it common "à de grandes profundeurs dans la mer." The species in its typical form extends up the west coast of America at least to the region off Central America where I have had it from depths of 428 to 730 fathoms. It occurs in well samples in the Pliocene of the Los Angeles Basin in rather typical form. The figured specimen is a recent one.

The peculiar plications figured by d'Orbigny are caused by alternating bands of thicker and thinner test forming plications at a slight angle to the costae.

BOLIVINA COSTATA d'Orbigny

Plate 6, fig. 2

Bolivina costata D'ORBIGNY, Voy. Amér. Mérid., vol. 5, pt. 5, "Foraminifères," 1839, p. 62, pl. 8, figs. 8, 9.

Test small, compressed, tapering, the periphery rounded, initial end broadly rounded in the megalospheric form, more pointed in the microspheric; chambers distinct, slightly if at all inflated; sutures distinct, oblique; wall ornamented with 5 to 7 costae on each side longitudinally continuous, of about equal size, the surface very thin and sharp, area between smooth, clearly perforate; aperture elongate, with a slight lip.

Length up to 0.75 mm.

d'Orbigny's types were from off Cobija, Peru.

The typical form with the characters described and figured by d'Orbigny occurs in the Pleistocene deposits of Lomita Quarry, Palos Verdes Hills, California, and in the eastern Pacific comes northward along the coast to at least the latitude of Central America.

In the Pliocene and Pleistocene of California this species is represented by the following varieties:

BOLIVINA COSTATA d'Orbigny, var. **INTERJUNCTA** Cushman, n. var.

Plate 6, fig. 3

Variety differing from the typical in the more elongate test, somewhat more compressed form, and especially in the orna-

mentation which in the early portion consists of several distinct costae as in the typical form but in the later portion these anastomose, and there are developed secondary transverse or oblique shorter costae connecting the primary ones.

Holotype of variety (Cushman Coll. No. 5567) from Lomita Quarry, Palos Verdes Hills, California, collected by Donald D. Hughes. It also occurs in the Upper and Middle Fernando of Ventura County and at Timms Point, San Pedro, California.

In the microspheric form the test is very acute, and the ornamentation much more strongly developed than in the megalospheric form shown here.

BOLIVINA COSTATA d'Orbigny, var. **BICOSTATA** Cushman, n. var.

Variety differing from the typical in having the two costae nearest the middle most strongly developed, and the others becoming obsolete in the adult portion, the sutures are somewhat limbate and raised above the surface.

Holotype of variety (Cushman Coll. No. 5569) from the Pliocene of Timms Point, San Pedro, California. It also occurs in the Upper Fernando of Ventura County, and occurs in the well samples of the Los Angeles Basin.

This remotely resembles some of the specimens that have been assigned by authors to *Bolivina acuariensis* (Costa). It is not that species but rather a variety of *B. costata*.

BOLIVINA ARGENTEA Cushman, n. sp.

Plate 6, fig. 5

Test elongate, very much compressed, periphery subacute, usually not keeled, the width after the first few chambers increasing slowly; chambers very distinct, narrow in the young, in the adult about 2½ times as long as broad; sutures oblique and curved, early ones limbate, later ones thin and somewhat depressed; wall very finely perforate, smooth except for the very base which occasionally has a trace of one or more costae on the proloculum and one or two following chambers; color of test light silvery gray, polished.

Length up to 0.80 mm.; breadth 0.40 mm.

Holotype (U. S. N. M. Coll. No. 20281) from *Lydonia* station 30, 7° 01′N.; 81° 48′W., in 428 fathoms. It also occurs farther north along the west coast of America at least to Oregon. In the Upper Pliocene of California it occurs in typical form with the same silvery gray test in well preserved specimens.

BOLIVINA PUNCTATA d'Orbigny

Bolivina punctata d'ORBIGNY, Voy. Amér. Mérid., vol. 5, pt. 5, "Foraminifères," 1839, p. 63, pl. 8, figs. 10-12.

There are smooth compressed forms with very distinct perforations which strongly resemble d'Orbigny's species from the Upper and Middle Fernando, near Ventura, and from the Pleistocene of Lomita Quarry, Palos Verdes Hills, California. The types were from off the coast of Chile.

BOLIVINA SEMINUDA Cushman

Bolivina seminuda CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 2, 1911, p. 34, fig. 55 (in text).

Test elongate, subcylindrical, very slightly compressed, initial end rounded; chambers numerous, high, very slightly inflated; sutures not depressed but distinct; wall hyaline, finely punctate, the lower half of each chamber with rather coarse foramina, the upper half clear; aperture elongate, loop-shaped, transparent except the lower part which is whitish.

Length up to 1 mm.; breadth 0.25 mm.; thickness 0.20 mm.

The originals were from Bering Sea. Specimens are very common southward along the Pacific coast as far at least as Panama. Similar specimens occur in the Middle and Upper Fernando of the California Pliocene. Occasionally specimens have the upper clear portion of the chamber reduced or wanting, and the whole becomes distinctly perforate.

BOLIVINA HUGHESI Cushman, n. sp.

Plate 6, figs. 4 *a*, *b*

Test elongate, slender, very slightly compressed, early portion gently tapering, later portion with the sides almost parallel, whole test twisted strongly, periphery rounded; chambers numerous, 12 or more pairs in the adult increasing in height toward the apertural end; sutures distinct, later ones distinctly depressed; wall smooth, very finely perforate, opaque.

Length up to 1 mm.; breadth 0.30 mm.; thickness 0.25 mm.

Holotype (Cushman Coll. No. 5584) from the Pliocene of San Jose Hills, California, collected by Donald D. Hughes. It also occurs in the Upper Fernando of Ventura County, California.

There is a tendency to develop one or more lobes near the inner margin on the lower line of each chamber, a feature which

becomes stronger in some specimens at different horizons in well samples, and making the species tend toward the conditions seen in *Bolivina decussata* H. B. Brady.

BOLIVINA DECURTATA Cushman, n. sp.

Plate 6, figs. 7 *a*, *b*

Test small, short and broad, periphery rounded, about 10 pairs of chambers, increasing slightly in height as added; sutures distinct, slightly limbate, only slightly oblique, curved, the chambers meet with very little overlapping giving a nearly straight suture along the median line; wall very finely perforate, smooth, opaque; aperture loop-shaped.

Length 0.55-0.60 mm.; breadth 0.35-0.40 mm.; thickness 0.12-0.15 mm.

Holotype (Cushman Coll. No. 5587) from the Pliocene of San Jose Hills, California, collected by Donald D. Hughes. This short broad species while common at this locality has not been noted elsewhere. It occasionally shows a slight twist in the very early chambers.

BOLIVINA SUBADVENA Cushman, n. sp.

Plate 6, figs. 6 *a*, *b*

Test stout, small, slightly twisted, periphery subacute; chambers distinct, usually 8 to 10 pairs, inflated, especially the later ones; sutures distinct, later ones depressed; wall roughened by the very coarse perforations, in some forms making a fine reticulation; aperture a broad loop, sub-terminal.

Length 0.65 mm.; breadth 0.25 mm.; thickness 0.12-0.15 mm.

Holotype (Cushman Coll. No. 5594) from the Pliocene of Timms Point, San Pedro, California. It also occurs in the Upper and Middle Fernando, and in the eastern Pacific along the coast at least from Oregon to Panama.

There are many varietal forms in the Pliocene of the Los Angeles Basin seen in well samples. The microspheric form is longer and much more tapering, the depression of the sutures and the inflation of the chambers much less, but the other characters are the same. The megalospheric proloculum is often very large in comparison with the size of the later chambers.

BOLIVINA SUBADVENA Cushman, n. sp., var. **SPISSA** Cushman, n. var.

Plate 6, figs. 8 *a*, *b*

Variety differing from the typical in having the sutures distinctly limbate and thickened along the median portion; the periphery acute, even slightly carinate, the initial end occasionally with a very slight apical spine, and in the megalospheric form traces of costae on the proloculum.

Holotype of variety (Cushman Coll. No. 5600) from the Pliocene of Timms Point, San Pedro, California. It also occurs in the Upper Fernando of Ventura County and at San Jose Hills, and in the Pleistocene of Lomita Quarry, Palos Verdes Hills as well as being a common variety in the Pliocene of wells in the Los Angeles Basin.

BOLIVINA PSEUDOBEYRICHI Cushman, n. sp.

Bolivina beyrichi Reuss, var. *alata* Cushman (not Seguenza), Bull. 71, U. S. Nat. Mus., pt. 2, 1911, p. 35, figs. 57 *a*, *b* (in text).

Test compressed, rather rapidly increasing in width, the chambers increasing in height as added, distinct, slightly inflated, periphery distinctly keeled, but those of each chamber distinct, the posterior angle produced and pointed; sutures distinct, depressed, slightly oblique, more strongly so in the earlier chambers; wall distinctly and coarsely perforate; aperture elliptical-oval, with a distinct raised lip.

Length 0.50-0.60 mm.; breadth 0.30-0.35 mm.; thickness 0.10-0.12 mm.

Holotype (U. S. N. M. Coll. No. 20282) from *Albatross* station H4025 in 536 fathoms near the Aleutian Islands. The species is widely distributed along the coast of the eastern Pacific extending along the coast southward at least to Panama at a depth of 300-500 fathoms where the water is cold. It also occurs in the upper part of the Pliocene of wells of the Los Angeles Basin. It is not at all the same as *B. beyrichi* from the Oligocene of Europe nor like the var. *alata* of Seguenza.

EXPLANATION OF PLATE 6

FIGS. 1 *a, b.* *Bolivina plicata* d'Orbigny. X 65.
a, front view; *b,* apertural view.

FIGS. 2 *a, b.* *Bolivina costata* d'Orbigny. X 65.
a, front view; *b,* apertural view.

FIG. 3. *Bolivina costata* d'Orbigny, var. *interjuncta* Cushman, n. var. X 65.

FIGS. 4 *a, b.* *Bolivina hughesi* Cushman, n. sp. X 50.
a, front view; *b,* apertural view.

FIG. 5. *Bolivina argentea* Cushman, n. sp. X 80.

FIGS. 6 *a, b.* *Bolivina subadvena* Cushman, n. sp. X 65.
a, front view; *b,* apertural view.

FIGS. 7 *a, b.* *Bolivina decurtata* Cushman, n. sp. X 65.
a, front view; *b,* apertural view.

FIGS. 8 *a, b.* *Bolivina subadvena* Cushman, n. sp., var. *spissa* Cushman, n. var. X 65.
a, front view; *b,* apertural view.

FIGS. 9–11. *Plectofrondicularia californica* Cushman and Stewart, n. sp. Fig. 9. Front view, X 50. Fig. 10. Outline of end view, X 50. Fig. 11. Section of early portion of microspheric form, X 75, dotted portion represents peripheral flange. Early chambers show a tendency to become coiled before taking on the biserial stage.


2b
1b
4b
2a
3
5
1a
7b
4a
8b
6b
7a
8a
6a
11
10
9

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the foraminifera that have come to hand.

Roig, Mario Sanchez Y.

Breve Resena Historica de la Paleontologia Cubana.

Soc. Geog. Cuba, Habana, 1926, pp. 1-15, 6 pls. *Havana.*

This paper mentions works on the foraminifera of Cuba, and gives a plate of figures made up from those published in the Carnegie Institution of Washington, Publ. 291.

Koch, R.

Mitteltertiäre Foraminiferen aus Bulongan, Ost-Borneo.

Ber. Schweizerischen Paläontologischen Gesellschaft, vol. 19, No. 3, 1926, pp. 722-751, with 26 text figs. *Basel.*

Two hundred and fifty-five species and forms are listed from the Middle Tertiary of East Borneo. A number of new species and varieties are described and figured, some of them of unusual interest.

Koch, R.

Miogypsina staufferi, nov. spec., from North-western Venezuela.

Ber. Schweizerischen Paläontologischen Gesellschaft, vol. 19, No. 3, 1926, pp. 751-753, pl. 28. *Basel.*

Figures and descriptions of this new species are given with a short discussion of its relationships to other species of the genus.

Yabe, H. and Hanzawa, S.

Notes on Some Tertiary Foraminiferous Rocks from the Philippines.

Sci. Rep. Tohoku Imp. Univ., sec. ser. (Geol.), vol. 7, No. 4, 1925, pp. 97-109 (1-13), pls. 25-27 (1-3). *Sendai.*

Notes are given on the foraminiferal fauna of six samples with a list of the species found. Three plates show many excellent reproductions from photographs of sections, particularly of orbitoids. Three new species and a new variety are described.

Schenck, H. G. and Aguerrevere, S. E.
Morphologic Nomenclature of Orbitoidal Foraminifera.
Amer. Journ. Sci., ser. 5, vol. 11, 1926, pp. 251-256, with 3 text figs. *New Haven.*
A number of descriptive terms are defined which will help to make more precise the descriptions of this group of foraminifera. A number of text figures illustrate the terms used.

Franke, A.
Die Foraminiferen der pommerschen Kreide.
Abhandl. geol. pal. Instit. Univ. Greifswald, vol. 6, 1925, pp. 1-96, pls. 1-8. *Greifswald.*
This paper deals with the foraminifera of the Cretaceous of this part of Germany. A large number of species are given and illustrated. A number of new forms are described. The classification adopted is that of Rhumbler bringing the Globigerininae as the most highly developed group of the last family of the Rotaliidae. This is an important paper for comparison with the American Cretaceous.

Hofker, J.
Die Foraminiferen aus den senon Limburgens.
Overdr. Natuurhist. Maandblad, Jaarg. 15, No. 3, 1926, pp. 29, 30, 1 pl. *Limburg.*
This paper gives copious notes and numerous figures of *Amphistegina fleuriausi* d'Orbigny.

Nuttall, W. L. F.
The Larger Foraminifera of the Upper Ranikot Series (Lower Eocene) of Sind, India.
Geol. Mag., vol. 63, 1926, pp. 112-121, pls. 10, 11, text figs. 1-3. *London.*
A number of species of various genera are described and figured including a new species of *Assilina* and of *Dictyoconoides.*

Nuttall, W. L. F.
Three Species of Lepidocyclines from Western India and Persia.
Ann. Mag. Nat. Hist., ser. 9, vol. 17, 1926, pp. 330-337, pl. 13, text figs. 1, 2. *London.*
Two of the species are from the Oligocene, the other described as new from the Miocene. The plate consists of excellent photographic figures.

Nuttall, W. L. F.

A Revision of the Orbitoides of Christmas Island.

Quart. Journ. Geol. Soc., vol. 82, 1926, pp. 22-42, pls. 4, 5, text figs. 1-3. *London.*

A review of the orbitoid foraminifera from this locality including the genera *Lepidocyclina, Spiroclypeus, Miogypsina,* and *Discocyclina,* with full descriptions and two plates from photographed sections. Three new species are described.

Silvestri, A.

Sulla Diffusione Stratigrafiva del Genere "Chapmania" Silv.

e Prev.

Mem. Pont. Accad. Sci. Nuovi Lincei, vol. 8, 1925, pp. 31-60, pl. 1, text figs. 1-10. *Roma.*

Many notes on this genus are given both from the point of view of distribution, structure, and nomenclature. Several new forms are described and a new genus, *Cushmania,* proposed.

Van der Vlerk, I. M.

A Study of Tertiary Foraminifera from the "Tidoengsche Landen" (E. Borneo).

Wetenschappelijke Mededeelingen, No. 3, 1925, pp. 13-38, pls. 1-6, text figs. *a, b,* with map.

An important paper on the macroscopic foraminifera of East Borneo, containing eight new species and one new variety with figures and description of others. The paper is illustrated by reproductions from photographs, the sections of which are unusually clear.

Van der Vlerk, I. M.

Het Foraminiferen genus Spiroclypeus en zi jn beteekenis voor de stratigraphie van het Tertiair van den Indo-Australischen Archipel.

Verhandl. Geol.-Mijn. Gei. Ned. Kol. Geol. Ser., vol. 8, 1925, pp. 561-567, text figs. 1-3. *The Hague.*

A general paper on this genus, especially its stratigraphic relations. The figures give horizontal and vertical sections and the terminology used.

Silvestri, Alfredo

Comme possa determinarsi l'eta delle rocce compatte organogeniche.

Ann. R. Liceo Sci., 1923-25 (1925), pp. 207-211, pl. 6. *Milan.*

A short paper on the subcarboniferous with a plate of sections of *Fusulina* and *Bigenerina.*

Hofker, J.

Die Foraminiferen aus dem senon Limburgens.

Nat. Maan., Nat. Gen. Limburg, Jaarg. 15, No. 4, April 30, 1926, pp. 38-42, pls. 1, 2. *Limburg.*

A paper devoted to exhaustive descriptive details with figures of *Orbitoides Faujasi* deFrance.

Martinotti, A.

Alcune Forme Notevoli della Microfauna di Gorbio (Alpi Marittime).

Atti Soc. Ital. Sci. Nat., vol. 64, 1925, pp. 175-180, pl. 6. *Pavia.*

A short paper on Eocene material including figures from Texas material referred to *Clavulina triquetra* Reuss.

CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

VOL. 2, PART 3, OCTOBER 1926

30. FORAMINIFERA OF THE TYPICAL MONTEREY OF CALIFORNIA

By Joseph A. Cushman

As there are so many different formation names applied to the Miocene of California without their exact correlation being known it seems wise to closely determine the faunas. The name Monterey was given to the Miocene shales in 1855 by William P. Blake (Proc. Acad. Nat. Sci. Philadelphia, vol. 7, 1855, pp. 328-331). The type locality is in the vicinity of Monterey. I have collections that may be considered typical: "Type locality, on road from Monterey to Pebble Beach, ¾ mile below Toll House on P. I. Co. road, collected by Hannibal and Waring, Stanford University locality 333"; also a similar lot of material from "Two miles south of Monterey, type locality." With these and abundant material in complete sections in San Luis Obispo County and elsewhere it seems very clearly that the typical Monterey is the upper portion of the section known as Monterey below the Santa Margarita sandstone. The foraminiferal fauna is very abundant in individuals and contains about sixty species and varieties. These species have now been worked out in such stratigraphic detail that it is possible to state that the two samples from south of Monterey are about 200 feet apart in the ideal section as now worked out. This upper typical Monterey is in many respects distinct from the lower portion of the shales such as those exposed at Henry Ranch and elsewhere.

This upper typical Monterey fauna has in great abundance *Nonionina medio-costata, costifera,* and *incisa* each of which has its particular place in the section. These do not occur in the lower Monterey so far as seen. Nodosarias are very few in the typical Monterey and but two species are represented while in the lower part they are very abundant and of many species. The large *Cristellaria beali* is very abundant and characteristic of the typical Monterey.

A very similar fauna is now living off the west coast of the United States and adjacent areas with many very closely related species. This relationship of the Miocene and Pliocene faunas with the fauna now living off the west coast will be discussed in a paper on the recent fauna soon to be published.

The close discrimination of these species of the typical Monterey will make possible a comparison with type material of the Maricopa, Modelo, Puente, Salinas, and Temblor, most of which have foraminifera, and in this way make more evident the relationships of the various portions of the section included under the name Monterey. Work is nearly completed on other parts of the section which will throw more light on the relationships. My thanks are due to the Geological Department of Stanford University for much material including the typical Monterey and to the Geological Department of the Marland Oil Company of California for the use of very excellent material from San Luis Obispo County. In order to avoid repetition yet make the faunal records complete, references are given to those species already described in these Contributions. The fauna is a very peculiar one as it is studied in complete detail as is also the Recent west coast fauna. All the figured specimens are from Section 24, T. 28 S., R. 14 E., San Luis Obispo Co., California.

BOLIVINA ADVENA Cushman

Contrib. Cushman Lab. Foram. Res., vol. 1, part 2, July 1925, p. 29, pl. 5, figs. 1 *a*, *b*.

BOLIVINA ADVENA Cushman, var. **ORNATA** Cushman

L. c., p. 29, pl. 5, figs. 2 *a*, *b*.

BOLIVINA ADVENA Cushman, var. **STRIATELLA** Cushman

L. c., p. 30, pl. 5, figs. 3 *a*, *b*.

BOLIVINA BREVIOR Cushman

L. c., p. 31, pl. 5, figs. 8 *a*, *b*.

BOLIVINA CALIFORNICA Cushman

L. c., p. 32, pl. 5, figs. 10 *a*, *b*.

BOLIVINA CONICA Cushman

L. c., p. 30, pl. 5, figs. 4 *a*, *b*.

BOLIVINA DECUSSATA H. B. Brady

L. c., p. 31, pl. 5, figs. 6 *a*, *b*.

BOLIVINA IMBRICATA Cushman

L. c., p. 31, pl. 5, figs. 7 *a*, *b*.

BOLIVINA MARGINATA Cushman

L. c., p. 30, pl. 5, figs. 5 *a*, *b*.

BOLIVINA TUMIDA Cushman

L. c., p. 32, pl. 5, figs. 9 *a*, *b*.

VIRGULINA CALIFORNIENSIS Cushman

L. c., p. 32, pl. 5, figs. 11 *a-c*.

BULIMINA OVATA d'Orbigny
Plate 7, fig. 1

Bulimina ovata D'ORBIGNY, Foram. Fossiles Vienne, 1846, p. 185, pl. 11, figs. 13, 14.

Test tapering, fusiform, greatest width above the middle, both ends rounded, longer than broad; chambers distinct, high, not greatly overlapping.

Length 0.60 mm.; breadth 0.30 mm.

This is close to the species described by d'Orbigny from the Miocene of the Vienna Basin.

BULIMINA OVULA d'Orbigny
Plate 7, fig. 2

Bulimina ovula D'ORBIGNY, Voy. Amér. Mérid., 1839, vol. 5, pt. 5, "Foraminifères," p. 51, pl. 1, figs. 10, 11.

Test nearly as broad as long, initial end pointed, greatest width at about the middle; chambers high, much overlapping.

Length 0.60 mm.; breadth 0.50 mm.

This is identical with the species described by d'Orbigny from the west coast of America.

BULIMINA PSEUDOTORTA Cushman, n. sp.
Plate 7, fig. 3

Test tapering, greatest breadth near the apertural end, outline slightly lobulate, initial end narrow, rounded, rapidly increasing in diameter to just below the broadly rounded or even truncate apertural end; chambers few, inflated; sutures distinct, very slightly depressed; wall thin, very finely perforate, smooth, matte; aperture either elongate or almost cruciform.

Maximum length 0.85 mm.; breadth 0.50 mm.

Holotype (Cushman Coll. No. 5703).

This resembles *B. torta* Cushman described from the North Pacific between the California coast and Hawaii.

BULIMINELLA BREVIOR Cushman
Contrib. Cushman Lab. Foram. Res., vol. 1, part 2, July 1925, p. 33, pl. 5, fig. 14.

BULIMINELLA CALIFORNICA Cushman
L. c., p. 33, pl. 5, fig. 15.

BULIMINELLA CURTA Cushman
L. c., p. 33, pl. 5, fig. 13.

BULIMINELLA SUBFUSIFORMIS Cushman
L. c., p. 33, pl. 5, fig. 12.

CASSIDULINA CRASSA d'Orbigny
Plate 7, figs. 4 *a*, *b*

Cassidulina crassa d'Orbigny, Voy. Amér. Mérid., 1839, vol. 5, pt. 5, "Foraminifères," p. 56, pl. 7, figs. 18-20.

A few specimens with broadly rounded periphery and nearly parallel sides seem referable to this species described by d'Orbigny in his South American Monograph.

CASSIDULINA LIMBATA Cushman and Hughes

Contrib. Cushman Lab. Foram. Res., vol. 1, part 1, April 1925, p. 12, pl. 2, figs. 2 *a-c*.

A few of the Monterey specimens may be referred to this species described from the Pliocene of California and now living off the western coast of America.

CASSIDULINA PULCHELLA d'Orbigny

L. c., vol. 1, part 2, July 1925, p. 34, pl. 5, fig. 16.

NODOSARIA OBLIQUA (Linné)
Plate 7, fig. 5

Nautilus obliquus Linné, Syst. Nat., ed. 10, 1758, p. 711; ed. 13 (Gmelin's), 1788, p. 3372.
Nodosaria obliqua (Linné), H. B. Brady, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 513, pl. 64, figs. 20-22.

Test fairly large, tapering, slightly curved; chambers of the later portion more distinctly inflated; wall smooth; aperture radiate, eccentric.

This is the only species of the genus at all common in the upper portion of the Monterey, and it continues into the Pliocene. It is usually broken in the preparation of material due to the stresses to which the shale has been subjected. The figured specimens are fragments from three portions of different specimens, and the complete specimen would be much more elongate than the position of the fragments on the plate would seem to indicate.

NODOSARIA KOINA Schwager
Plate 7, fig. 6

Nodosaria koina Schwager, *Novara*-Exped., Geol. Theil., pt. 2, 1866, p. 220, pl. 5, fig. 47.

Test slender, slightly curved, very gently tapering, initial end rounded; chambers numerous, ten or more, inflated, gradually increasing in size as added; sutures distinct, but only slightly depressed; wall smooth, matte; aperture radiate, nearly central.

Length up to 1.30 mm.; greatest breadth 0.28 mm.

Schwager described this species from the Pliocene of Kar Nicobar, and his figured specimens appear to be identical with the Monterey species. This is probably the species referred by Chapman (Proc. Cal. Acad. Sci., ser. 3 (Geol.), vol. 1, No. 8, 1900, pl. 29, fig. 11) to *Nodosaria radicula* Linné.

NODOSARIA KOINA Schwager, var. **HUGHESI** Cushman, n. var.
Plate 7, fig. 7

Variety differing from the typical in the peculiar form of the chambers which at the base are slightly expanded and then cut under sharply.

Holotype of variety (Cushman Coll. No. 5688).

This variety occurs in a very narrow band of the section. It is named for Mr. Donald D. Hughes who first called my attention to the differences between this and the foregoing.

CRISTELLARIA BEALI Cushman

Contrib. Cushman Lab. Foram. Res., vol. 1, part 1, April 1925, p. 25, pl. 4, figs. 6-13.

CRISTELLARIA MIOCENICA Chapman
Plate 7, fig. 8

Cristellaria miocenica CHAPMAN, Proc. Cal. Acad. Sci., ser. 3 (Geol.), vol. 1, 1900, p. 250, pl. 30, figs. 1, 1*a*.

This is apparently the species described by Chapman from the Monterey in the above reference.

There are several other species of *Cristellaria* from the upper Monterey, but they are smooth and not well characterized. They are left for the present without specific determination.

FRONDICULARIA FOLIACEA Schwager
Plate 7, fig. 9

Frondicularia foliacea SCHWAGER, *Novara*-Exped., Geol. Theil, pt. 2, 1866, p. 236, pl. 6, fig. 76.

Test elongate, tapering, very much compressed, periphery subacute; chambers few, distinct, elongate; sutures distinct, slightly depressed, nearly straight; wall very thin, finely perforate, matte; proloculum thicker than the remainder of the test.

This species is rare, but the specimens are very similar to those figured and described by Schwager from the Pliocene of Kar Nicobar.

PLECTOFRONDICULARIA MIOCENICA Cushman, n. sp.

Plate 7, figs. 10, 11; plate 8, figs. 11, 12

Test elongate, narrow, gradually tapering, very much compressed, periphery acute, keeled; chambers numerous, distinct, elongate, early ones biserial, alternating; sutures distinct, slightly depressed, curved; wall very thin except in the earlier chambers which are thickened, ornamented by a few longitudinal costae, strongest over the proloculum thence gradually spreading and decreasing in size.

Length 1.75 mm.; breadth 0.65 mm.

Holotype (Cushman Coll. No. 5701).

This is apparently the ancestral form of the Pliocene *P. californica* Cushman and Stewart. It is much broader, and only the earlier portion is keeled.

Subgenus UVIGERINELLA Cushman, new subgenus

The species here referred to *Uvigerina* are characterized by a peculiar set of apertural characters. Instead of a definite tubular neck there is an elevated "collar" about the aperture, the inner sides of which often do not meet but run down the sides of the test about the aperture. The aperture itself instead of being circular as in typical *Uvigerina* is elliptical and has usually a valvular tooth. This seems to be a unique development in this particular region in the Miocene. This type species is *Uvigerina* (*Uvigerinella*) *californica* Cushman, n. sp.

UVIGERINA (UVIGERINELLA) CALIFORNICA Cushman, n. sp.

Plate 8, figs. 2 *a*, *b*, 5

Test much longer than broad, greatest breadth near the apertural end, composed of 6 or 7 whorls; chambers distinct, inflated, 3 in each whorl, arranged in longitudinal series but slightly twisted so that each vertical series makes about ¼ turn of the test, last-formed chamber often slightly irregular; sutures distinct, depressed; wall smooth, finely perforate; aperture with a very short neck, not cylindrical, but somewhat compressed, from the inner portion of the chamber a very slight phialine lip, and in some specimens apparently an apertural tooth, thin, plate-like, projecting in from the inner side of the aperture.

Length up to 1 mm.; breadth 0.30 mm.

Holotype (Cushman Coll. No. 5739).

UVIGERINA (UVIGERINELLA) CALIFORNICA Cushman, n. sp., var. ORNATA Cushman, n. var.

Plate 8, figs. 1 *a-c*, 6

Variety differing from the typical in the shorter test, usually not having more than 6 whorls, the surface ornamented with numerous distinct, longitudinal costae.

Holotype of variety (Cushman Coll. No. 5751).

UVIGERINA (UVIGERINELLA) NUDO-COSTATA Cushman, n. sp.

Plate 8, figs. 4 *a-c*, 8

Test small, elongate, tapering, broadest toward the apertural end; chambers numerous, inflated; sutures depressed, distinct; wall in the early chambers very finely costate, in the later ones smooth; aperture terminal, rather large, with a low lip or collar, open on the inner border and with a slight apertural tooth.

Length 0.50 mm.; breadth 0.22 mm.

Holotype (Cushman Coll. No. 5758).

This is somewhat smaller than the other species, and is more regular in the placing of the chambers.

UVIGERINA (UVIGERINELLA) OBESA Cushman, n. sp.

Plate 8, figs. 3 *a-c*, 7

Test elongate, fusiform, greatest width above the middle; chambers numerous, inflated; sutures deeply depressed, the posterior portion of the later chambers overhanging; wall with numerous fine costae, those of each chamber independent of adjacent ones; aperture terminal, with a short neck and somewhat phialine lip usually open at the inner end.

Length 0.50-0.60 mm.; breadth 0.25-0.28 mm.

Holotype (Cushman Coll. No. 5757).

SIPHOGENERINA COLLOMI Cushman

Contrib. Cushman Lab. Foram. Res., vol. 1, part 1, April 1925, p. 2, pl. 4, fig. 3.

SIPHOGENERINA KLEINPELLI Cushman

L. c., p. 3, pl. 4, fig. 5.

SIPHOGENERINA REEDI Cushman

L. c., p. 3, pl. 4, fig. 4.

Genus VALVULINERIA Cushman, new genus

Test usually trochoid, close coiled, all chambers of the several coils visible from the dorsal side, only those of the last-formed coil from the ventral side, umbilicate; chambers numerous; wall

finely perforate; the aperture ventral, large, extending from the umbilical end of the chamber nearly to the periphery and covered by a thin, membrane-like plate which largely fills the umbilical area, in the adult the aperture often extends into the ventral or peripheral face of the chamber, sometimes becoming tripartite.

There is a very great development of this genus in the Miocene of the California region and the species take on various forms. In some of them the spire becomes depressed and the later chambers overlap those of the earlier coils on the dorsal side, in others the reverse appears and the last-formed coil becomes much more ventral. The apertural characters are very peculiar and will distinguish the genus. Recent species from off the west coast of America also belong here. There was evidently rapid evolution taking place at this time, as in the very complete sections studied it is possible to trace the rapid changes in the species of this genus that take place at succeeding levels. Genotype, *Valvulineria californica* Cushman, n. sp.

VALVULINERIA CALIFORNICA Cushman, n. sp.
Plate 9, figs. 1 *a-c*

Test large, rounded, rotaliform, periphery broadly rounded, in the adult the last coil narrow on the dorsal side, the chambers overlapping the preceding coil very slightly, 6-8 chambers in the last-formed coil; sutures distinctly limbate; aperture ventral, from the umbilicus slightly out onto the ventral margin.

Length 0.65-0.80 mm.; breadth 0.60 mm.; thickness 0.50-0.55 mm.

Holotype (Cushman Coll. No. 5798).

VALVULINERIA CALIFORNICA Cushman, n. sp., var. **APPRESSA** Cushman, n. var.

Plate 9, figs. 5 *a-c*

Variety differing from the typical in the more rotaliform test, broader in end view, in the adult the chambers on the dorsal side somewhat covering the preceding coil, ventral side more extended, peripheral margin broader, plate-like extension very distinct, later chambers on the dorsal side more inflated; sutures more distinct and depressed; chambers 6-8; aperture almost umbilical.

Length 1 mm.; breadth 0.90 mm.; thickness 0.50 mm.

Holotype of variety (Cushman Coll. No. 5814).

VALVULINERIA CALIFORNICA Cushman, n. sp., var. **OBESA** Cushman, n. var.

Plate 9, figs. 2 *a-c*

Test with a very rounded periphery, the chambers comparatively few, earlier chambers exposed on the dorsal side, inflated, in peripheral view the test nearly equilateral.

Length 0.60-0.95 mm.; breadth 0.50-0.80 mm.; thickness 0.42-0.60 mm.

Holotype of variety (Cushman Coll. No. 5804).

VALVULINERIA MIOCENICA Cushman, n. sp.

Plate 8, figs. 9, 10; plate 9, figs. 3 *a-c*

Test longer than broad, plano-convex, dorsal side flattened, ventral side convex, periphery broadly rounded in final chambers, in earlier ones often bluntly angled; chambers increasing much in height, especially in the last-formed portion, 8-10 in the last-formed coil, the last few inflated; sutures limbate; wall coarsely perforate; aperture slightly on the ventral side of the periphery in some specimens with the aperture developing long projections across the apertural face even becoming tripartite as in pl. 8, figs. 9, 10.

Length 0.70 mm.; breadth 0.55 mm.; thickness 0.35 mm.

Holotype (Cushman Coll. No. 5789).

VALVULINERIA MIOCENICA Cushman, n. sp., var. **DEPRESSA** Cushman, n. var.

Plate 9, figs. 7 *a-c*

Test small, nearly bilaterally symmetrical, periphery evenly rounded, dorsal side almost completely involute, only a very little of the previous coil showing, ventral side deeply umbilicate, 8 or 9 chambers in the last-formed coil; chambers somewhat inflated; sutures distinct, depressed; aperture extending nearly to the median line from the ventral side.

Length 0.50 mm.; breadth 0.40 mm.; thickness 0.28 mm.

Holotype of variety (Cushman Coll. No. 5783).

VALVULINERIA ORNATA Cushman, n. sp.

Plate 9, figs. 4 *a-c*

Test nearly bilaterally symmetrical, longer than broad, periphery rounded, about 10 chambers in the last-formed coil; chambers not greatly inflated; sutures limbate, distinct, very broad toward the umbilicus; wall coarsely and distinctly perforate, the perforations showing a tendency to be arranged in somewhat radial lines.

Length 0.60 mm.; breadth 0.45 mm.; thickness 0.32 mm. Holotype (Cushman Coll. No. 5810).

VALVULINERIA VILARDEBOANA (d'Orbigny)

Plate 9, figs. 6 *a-c*

Rosalina vilardeboana d'ORBIGNY, Voy. Amér. Mérid., 1839, vol. 5, pt. 5, "Foraminifères," p. 44, pl. 6, figs. 13-15.

Test biconvex, periphery slightly rounded or bluntly angled, 4 or 5 chambers in the last-formed coil, flattened; sutures fairly distinct, very slightly depressed, more so on the ventral side; wall roughened slightly with coarse perforations; aperture a low. elongate, arched slit on the ventral side extending from the umbilicus to the periphery.

Length 0.40 mm.; breadth 0.35 mm.; thickness 0.18 mm.

This is apparently the same as the species described by d'Orbigny from the coast of South America. It belongs in the genus with the other species described here.

TRUNCATULINA cf. BASILOBA Cushman

Test plano-convex, dorsal side nearly flat, ventral side somewhat convex, periphery subacute; chambers fairly distinct, 8-10 in the last-formed coil, the inner angle of each chamber on the dorsal side ending in a small, overlapping, rounded lobe, leaving a flat ring about the umbilicus outside of which is a series of depressions, one for each chamber; sutures slightly depressed, fairly distinct; wall rather coarsely perforated; aperture near the edge on the ventral side.

Length 0.45-0.60 mm.; breadth 0.35-0.50 mm.

This very strikingly resembles a species I have described from the Miocene of South Carolina (Bull. 676, U. S. Geol. Survey, 1918, p. 64, pl. 21, fig. 2).

Genus PULVINULINELLA Cushman, new genus

Test trochoid, close coiled, all the chambers visible from the dorsal side, only those of the last-formed coil from the ventral side, very slightly umbilicate; chambers numerous and distinct; sutures on the dorsal side oblique, on the ventral side nearly radial; wall thin, finely perforate; aperture on the ventral side of the peripheral face, elongate, somewhat loop-shaped, nearly parallel to the axis of coiling, sometimes with a slight tooth-like projection of the margin on one side.

There is but a single species present in the upper Monterey,

but in the lower portion and especially off the west coast of America in the present ocean there is a very considerable development of this genus. The type species, *Pulvinulinella subperuviana* Cushman, n. sp., does not show the apertural characters as definitely as do the recent species. In these there is a tendency for the last-formed chambers to become slightly Cassiduline and the aperture is very similar to that of *Cassidulina*. It may be that this is the form from which *Cassidulina* originated, and that *Cassidulina* is a biserially arranged offshoot from the Rotaliidae. A further discussion of this genus will be deferred until the recent species are described.

PULVINULINELLA SUBPERUVIANA Cushman, n. sp.

Plate 9, figs. 9 *a-c*

Test small, rotaliform, biconvex, umbonate, periphery subacute; chambers numerous, 10 or 11 in the last-formed coil; sutures on the dorsal side strongly oblique, on the ventral side nearly straight, radial, distinct but only slightly depressed; last-formed coil thin and compressed forming a fringe about the more umbonate center; wall smooth; aperture a narrow slit on the ventral side of the last-formed chamber just below and parallel with the periphery, with a tooth-like projection from the edge.

Diameter 0.40 mm.

Holotype (Cushman Coll. No. 5825).

This in some respects resembles the *Rosalina peruviana* of d'Orbigny from the coast of South America. It has fewer chambers and much less definite coils. d'Orbigny's description and figure of the aperture leave much to be desired, but it probably belongs to this genus.

Genus **BAGGINA** Cushman, new genus

Test subglobular, trochoid, chambers relatively few, arranged in three or more coils, the dorsal side with the chambers more or less involute, the ventral side completely so; chambers large and inflated; sutures distinct but very slightly depressed; wall calcareous, finely perforate with a clear lunate space on the ventral side of the chamber near the aperture; aperture broadly oval on the ventral side of the last-formed chamber without a definite lip. Genotype, *Baggina californica* Cushman, n. sp.

This genus is named in honor of Dr. Rufus M. Bagg, Jr., an American worker on the Foraminifera for many years. Some of the recent Pacific species should probably be referred to this genus.

BAGGINA CALIFORNICA Cushman, n. sp.

Plate 9, figs. 8 *a-c*

Test subglobular, the last-formed coil only visible from the ventral side, not completely covering the earlier ones on the dorsal side, periphery broadly rounded; chambers comparatively few, 5 in the last-formed coil, inflated, rather indistinct; sutures fairly distinct, hardly depressed except slightly so on the ventral side; wall smooth; aperture large and elliptical on the ventral side of the last-formed chamber near the umbilicus; each chamber with the wall finely and closely perforate except in a semi-elliptical area above the umbilicus which is apparently thinner, of clear material with few or no perforations.

Length 0.75 mm.; breadth 0.60 mm.; thickness 0.60 mm.

Holotype (Cushman Coll. No. 5777).

This species is especially characteristic of the upper part of the Monterey.

Genus **NONIONELLA** Cushman, new genus

Test subtrochoid, the dorsal side only partially involute, ventral side completely so, close coiled; chambers especially in the adult inaequilateral, the ventral side developing a distinct elongate lobe at the umbilical end which covers the umbilicus; wall calcareous, finely perforate; aperture at the base of the chamber, low and elongate, extending from the peripheral border toward the ventral side.

Genotype, *Nonionella miocenica* Cushman, n. sp.

The species of this genus have usually been placed under *Nonionina*, but this distinct subtrochoid character with the lobed ventral side and inaequilateral aperture persists through many species at least from the early Eocene to the present. It seems worthy of generic distinction.

NONIONELLA MIOCENICA Cushman, n. sp.

Nonionina auris CUSHMAN (not D'ORBIGNY), Contrib. Cushman Lab. Foram. Res., vol. 1, part 4, 1926, p. 91, pl. 13, figs. 4 *a-c*.

Test subtrochoid, small, periphery broadly rounded, 8-10 chambers in the last-formed coil, distinct, dorsal side not completely involute; the sutures obliquely curved, the last chambers with the umbilical end forming a distinct, rounded lobe; wall smooth; aperture low, elongate.

Length 0.45 mm.; breadth 0.35 mm.; thickness 0.25 mm.

Holotype (Cushman Coll. No. 4370).

This species has fewer chambers than *Nonionella auris* (d'Orbigny), and holds its characters in the upper Monterey very closely.

NONIONINA COSTIFERA Cushman

L. c., p. 90, pl. 13, figs. 2 *a-c*.

NONIONINA INCISA Cushman

L. c., p. 90, pl. 13, figs. 3 *a-c*.

NONIONINA MEDIO-COSTATA Cushman

L. c., p. 89, pl. 13, figs. 1 *a-c*.

The number of species and genera described as new from this upper Monterey material may seem large, but as the collections have been more and more thoroughly studied the differences between this Miocene and other known faunas have become more and more apparent. It is most closely related to a very interesting fauna now living off this same coast. There are a very few species related to the Miocene of other regions and to the Pliocene of the general Pacific region, but the number is very small. Paratypes of most of these species are to be found in the collections of Stanford University.

EXPLANATION OF PLATE 7

FIG. 1. *Bulimina ovata* d'Orbigny. X 65.
FIG. 2. *Bulimina ovula* d'Orbigny. X 65.
FIG. 3. *Bulimina pseudotorta* Cushman, n. sp. X 65.
FIGS. 4 *a, b*. *Cassidulina crassa* d'Orbigny. X 65.
FIG. 5. *Nodosaria obliqua* (Linné). X 65. Three fragments of different parts of test.
FIG. 6. *Nodosaria koina* Schwager. X 65.
FIG. 7. *Nodosaria koina* Schwager, var. *hughesi* Cushman, n. var. X 65.
FIG. 8. *Cristellaria miocenica* Chapman. X 65.
FIG. 9. *Frondicularia foliacea* Schwager. X 65.
FIGS. 10, 11. *Plectofrondicularia miocenica* Cushman, n. sp. X 65.

EXPLANATION OF PLATE 8

FIGS. 1 *a–c*. *Uvigerina* (*Uvigerinella*) *californica* Cushman, n. sp., var. *ornata* Cushman, n. var. X 65. *a*, side view; *b*, front view; *c*, apertural view.
FIGS. 2 *a, b*. *Uvigerina* (*Uvigerinella*) *californica* Cushman, n. sp. X 65. *a*, side view; *b*, apertural view.
FIGS. 3 *a–c*. *Uvigerina* (*Uvigerinella*) *obesa* Cushman, n. sp. X 65. *a*, front view; *b*, side view; *c*, apertural view.
FIGS. 4 *a–c*. *Uvigerina* (*Uvigerinella*) *nudo-costata* Cushman, n. sp. X 65. *a*, side view; *b*, front view; *c*, apertural view.
FIG. 5. *Uvigerina* (*Uvigerinella*) *californica* Cushman, n. sp. X 75.
FIG. 6. *Uvigerina* (*Uvigerinella*) *californica* Cushman, n. sp., var. *ornata* Cushman, n. var. X 75.
FIG. 7. *Uvigerina* (*Uvigerinella*) *obesa* Cushman, n. sp. X 75.
FIG. 8. *Uvigerina* (*Uvigerinella*) *nudo-costata* Cushman, n. sp. X 75.
FIGS. 9, 10. *Valvulineria miocenica* Cushman, n. sp. Two forms of aperture. X 50.
FIGS. 11, 12. *Plectofrondicularia miocenica* Cushman, n. sp. Early chambers.

EXPLANATION OF PLATE 9

FIGS. 1 *a–c*. *Valvulineria californica* Cushman, n. sp. X 65.
a, ventral view; *b*, dorsal view; *c*, peripheral view.
FIGS. 2 *a–c*. *Valvulineria californica* Cushman, n. sp., var. *obesa* Cushman, n. var. X 65.
a, ventral view; *b*, dorsal view; *c*, peripheral view.
FIGS. 3 *a–c*. *Valvulineria miocenica* Cushman, n. sp. X 65.
a, ventral view; *b*, dorsal view; *c*, peripheral view.
FIGS. 4 *a–c*. *Valvulineria ornata* Cushman, n. sp. X 65.
a, ventral view; *b*, dorsal view; *c*, peripheral view.
FIGS. 5 *a–c*. *Valvulineria californica* Cushman, n. sp., var. *appressa* Cushman, n. var. X 65.
a, ventral view; *b*, dorsal view; *c*, peripheral view.
FIGS. 6 *a–c*. *Valvulineria vilardeboana* (d'Orbigny). X 65.
a, ventral view; *b*, dorsal view; *c*, peripheral view.
FIGS. 7 *a–c*. *Valvulineria miocenica* Cushman, n. sp., var. *depressa* Cushman, n. var. X 65.
a, ventral view; *b*, dorsal view; *c*, peripheral view.
FIGS. 8 *a–c*. *Baggina californica* Cushman, n. sp. X 65.
a, ventral view; *b*, dorsal view; *c*, peripheral view.
FIGS. 9 *a–c*. *Pulvinulinella subperuviana* Cushman, n. sp. X 100.
a, ventral view; *b*, dorsal view; *c*, peripheral view.


1


2


3


4b


4a


6


7

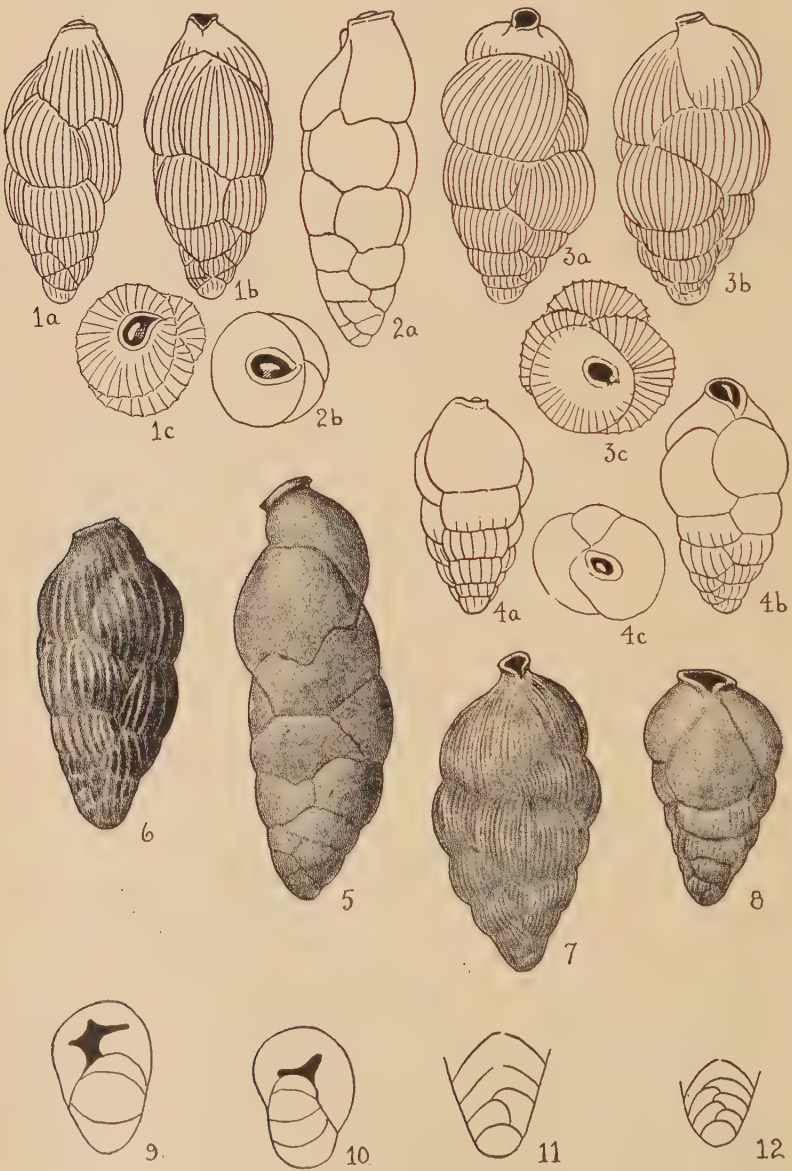

8


5


9


10


11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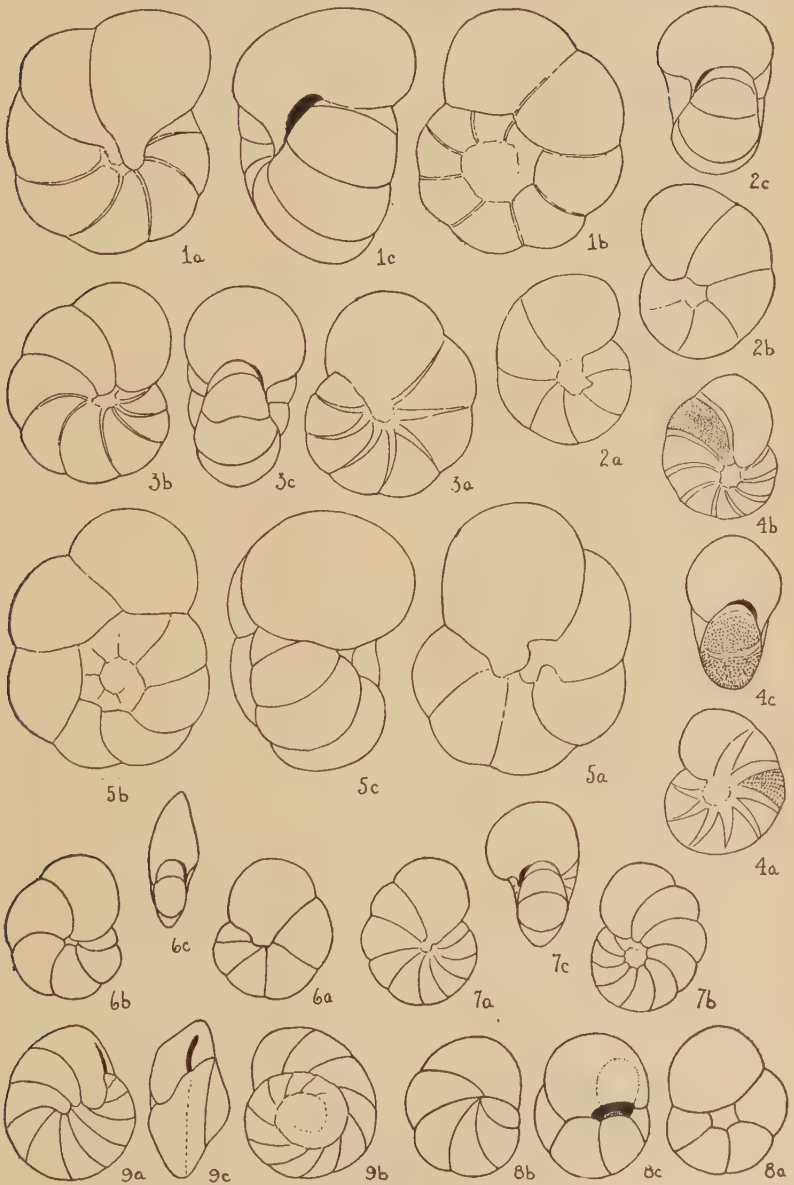
1a
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6c
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7a
7c
7b
9a
9c
9b
8b
8c
8a

31. THE GENERIC POSITION OF "*PULVINULINA FAVUS* H. B. BRADY"

By Joseph A. Cushman

The very peculiarly ornamented species described by Brady as *Pulvinulina favus* is common in some parts of the Pacific. It is a species characterized particularly "by a thick exogenous deposit of shell-substance, forming a 'honeycomb' ornament not unlike that of *Lagena squamata* or *Lagena hexagona*, over almost the entire surface of the test."

The aperture is not that of *Pulvinulina* and with numerous specimens at hand sections were made. These show a very thick, almost friable covering of the harder test, and when the sections are studied the species turns out, as was suspected, not a *Pulvinulina* but a true *Cassidulina*. Brady's own section, *Challenger* Report, pl. 104, fig. 14, also shows on close study that the alternate chambers do not reach the center in the median section, and should have given the clue to its relationship.

In its surface ornamentation *Cassidulina favus* (H. B. Brady) is somewhat similar to *C. decorata* Sidebottom and *C. elegantissima* Cushman both known only from the Pacific. *Cassidulina favus* is primarily a cold water species of comparatively deep waters of the Pacific. The references to it are as follows:

CASSIDULINA FAVUS (H. B. Brady)

Pulvinulina favus H. B. Brady, Geol. Mag., Dec. 2, vol. 4, 1877, p. 294; Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 701, pl. 104, figs. 12-16.—Chapman, Journ. Linn. Soc., Zool., vol. 30, 1910, p. 423, pl. 55, fig. 15.—Schubert, Abhandl. geol. Reichsanst, vol. 20, pt. 4, 1911, p. 113.—Pearcey, Trans. Roy. Soc. Edinburgh, vol. 49, 1914, p. 1029.—Cushman, Bull. 71, U S. Nat. Mus., pt. 5, 1915, p. 65.—Heron-Allen and Earland, British Antarctic Exped., Zool., vol. 6, 1922, p. 219.—Cushman, Publ. 342, Carnegie Inst., Washington, 1924, p. 42, pl. 13, figs. 7, 8.

The *Challenger* specimens were from deep water of the Pacific. Chapman's specimens are from off Funafuti, 1050-2728 fathoms. Pearcey records it from the Antarctic 1998 fathoms. I had it from numerous North Pacific stations, 847-2250 fathoms. A single specimen from Samoa is referred to it.

As a fossil it was described by Brady from the Pacific, and is recorded from the Bismarck Archipelago by Schubert. Heron-Allen and Earland record it fossil from the Antarctic, "not typical."

Egger (Abhandl. kön. bay. Akad. Wiss. München, Cl. II, vol. 18, 1893, p. 417, pl. 18, figs. 13-15) records this species in comparatively shallow water from Cape of Good Hope and from Mauritius, but his figures do not give a very good representation of this species. The ventral side shows a deeply umbilicate specimen, and the dorsal side is very distinctly trochoid. Halkyard (Mem. Proc. Manchester Lit. Philos. Soc., vol. 62, pt. 2, 1918 (1919), p. 123) records this species from the Eocene Blue Marl of Biarritz. He notes as do also Heron-Allen and Earland who edited his paper that the specimens are not the same as that of the Pacific in their characters, and they undoubtedly are another thing.

32. SOME PHASES OF CORRELATION BY MEANS OF THE FORAMINIFERA

By Joseph A. Cushman

While the foraminifera furnish excellent means for correlation often over wide distances, there are certain limitations that a beginner in the work may not take into consideration, and which should be understood. As to the general age of deposit the foraminifera are very excellent if one is sufficiently familiar with faunas. In the Palaeozoic the forms were widely spread, and the presence of certain genera will in any part of the world give the general age of the Mississippian or the Uralian.

With the Cretaceous also there are many genera that will at once in any part of the world give the clue to the certain Cretaceous age of the deposits containing them. Also the faunas of various parts of the world were fairly uniform, and there are many species common to Europe and America for instance. A study of the Cretaceous of Mexico or of the coastal plain region of the United States must be made in connection with the literature and if possible the comparison with European material. Many of the species will be found to be identical. Rather widely separated areas will be found to have had the same species at the same age, and distributions of known species are wide at the

same time, and a definite horizon may be correlated over wide distances.

With the Tertiary this possibility of correlation is no longer so definite. To be sure some of the Orbitoid forms, as well as Nummulites and other genera are limited to the Eocene but they are no longer distributed so widely or at least not over such definite areas. They have become specialized as to habitat to a greater extent than was apparent in the Cretaceous and earlier periods. The genus *Hantkenina* is an excellent Eocene index fossil, but it is limited in its habitat to a much deeper and probably colder water than is the case with the others mentioned. In America for example *Hantkenina* is known from the region of Alabama around the Gulf through the Gulf States into Mexico and South America, but is always associated with deeper and colder water forms. On the other hand the species of *Discocyclina* are equally widely distributed but much more local as they were characteristic of shallow warmer waters which were not as widely distributed a habitat as was the deeper colder water.

The fauna so abundantly developed on the coastal plain region of Florida and closely adjacent regions which make up the Ocala limestone was very different from that developed in the deeper colder waters even of the same time along its borders. The contrast in the faunas is very great, and very few of the species of the one fauna occur at all in the other. It may even be said that the fauna of the colder and deeper habitats is more closely related to the living fauna of the Gulf and the Atlantic coast than it is to the contemporaneous Ocala limestone fauna. The species of the shallower water were probably as is the case today more specialized in their ecologic relations, and therefore could not exist over as great areas as could those of deeper colder waters. If the conditions continued however these species persisted and gave rise to others which were specially adapted to similar habitats. For example, *Valvulina ocalana* Cushman which was often abundant on the shallow water, warm portions of the Ocala Sea is very closely related to *V. oviedoiana* d'Orbigny which is found in great abundance on the coral reef regions of the general West Indian region today and to a similar species found in similar habitats in the Indo-Pacific. Habitat then in the Tertiary has played a very prominent part in the distribution of faunas and their constituent species.

The Oligocene continues even more strikingly this same character. Species and genera of various groups of animals which lived in the West Indian region in Oligocene times were not able

to persist through the Miocene changed conditions but still exist in the Indo-Pacific under similar conditions, which they earlier found in the West Indian Oligocene Sea. Many of the smaller foraminifera species of the shallower portions of the American Oligocene must be compared with their living relatives now found only in the Indo-Pacific. This relationship is very much closer than any found in the Miocene or Pliocene of the general Gulf or West Indian regions.

The Miocene of the eastern and Gulf Coastal Plain has very little in common with the Miocene of the California region. Specialization to habitat has become very great. The foraminiferal fauna of the Miocene of the Bowden marl of Jamaica for example has little or nothing in common with the Miocene of the general coastal plain area or with that of the Monterey of California. It is strikingly like a peculiar fauna found off the Barbadoes at a depth of a hundred fathoms and at certain other favored spots in the same region. Here the same or very closely related species are now living in very considerable numbers as they did in the Bowden area during the Miocene. Not one of the large and striking species occurs in the Miocene of California or even of the general coastal plain region of our southeastern states.

The Pliocene of the Caloosahatchee marl of Florida has practically nothing in common with the Pliocene of the California region. The Caloosahatchee was very definitely a warm rather shallow habitat such as exists today off the southern coast of Florida and in the West Indies where most of the same species are now living. No species of *Bolivina, Cassidulina, Nodosaria* or *Uvigerina* occurs in the Caloosahatchee marl, yet these are the common and dominant genera in the Pliocene of California, and represent genera of cooler deeper waters, and are abundant and dominant in the bottom deposits of such conditions existing off the western coast. In fact many if not most of the species of the California Pliocene exist today in the cooler waters off the coast from Panama to Oregon and Washington. *Cassidulina* for example is so abundant at some localities off the western coast of America that I have seen *Albatross* bottom samples which had probably ninety-five percent of the foraminifera belonging to different species of *Cassidulina,* and the bottom might almost be characterized as a "*Cassidulina*-mud."

Enough examples have perhaps been given to show that in the Tertiary at least the foraminifera have come to be very specialized as to habitat, and while they give most excellent correla-

tion over shorter distances and over long ones when ecologic conditions were similar, they may be very misleading, unless a considerable amount is known of the recent faunas of the same general areas and the genera and species that occur under certain habital conditions. As more is known of these faunal associations with habitat, the foraminifera will become ever more valuable as a means of interpretation of the conditions of deposition of many of our Tertiary deposits.

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the foraminifera that have come to hand.

Hofker, J.
Die Foraminiferen aus dem senon Limburgens. IV. *Sporadotrema errantium,* nov. spec.
(Nat. Maan., Nat. Gen. Limburg, Jaarg. 15, No. 6, June 30, 1926, pp. 62-65, 1 plate.) *Limburg.*
A paper devoted to exhaustive descriptive details with numerous figures of this new species.

Franke, A.
Die Foraminiferen des norddeutschen Unter-Oligocäns mit besonderer Berücksichtigung der Funde an der Fritz-Ebert-Brücke in Magdeburg.
(Abhandl. und Berichte Mus. Natur-und Heimatkunde und Nat. Ver., Bd. 4, Heft 2, 1925, pp. 146-190, pls. 5, 6.) *Magdeburg.*
This paper contains 73 species from the Lower Oligocene, 3 of which are described as new.

Darton, N. H.
Geology of the Guantanamo Basin, Cuba.
(Journ. Washington Acad. Sci., vol. 16, No. 12, June 1926, pp. 324-332, 5 text figs.) *Washington.*
Three lists of foraminifera are given from this region of Cuba.

Galloway, J. J.
Methods of Correlation by Means of Foraminifera.
(Bull. Amer. Assoc. Petr. Geol., vol. 10, No. 6, June 1926, pp. 562-567.) *Chicago.*
"The determined principles of paleontologic correlation are applied to the use of Foraminifera for age determination and horizon identification and the relative values of the different criteria are briefly considered in this paper."—Author's abstract.

Cushman, Joseph A.

The Foraminifera of the Velasco Shale of the Tampico Embayment.

(Bull. Amer. Assoc. Petr. Geol., vol. 10, No. 6, June 1926, pp. 581-612, pls. 15-21.) *Chicago.*

"This paper describes and illustrates the foraminiferal fauna of the Velasco shale which occurs above the Papagallos in the Tampico Embayment region. The species are very numerous and show very interesting relationships with a fauna of similar age in Europe."—Author's abstract.

Carsey, Dorothy Ogden.

Foraminifera of the Cretaceous of Central Texas.

(Univ. of Texas Bulletin, No. 2612, July 1926, pp. 1-56, pls. 1-8.) *Austin.*

According to the author this paper "was prepared to serve as a practical working basis for the study of the subsurface geology of the Cretaceous sediments of Central Texas." The different formations are taken up and a short description of the appearance given with a list of the foraminifera found in each. The latter part is taken up by description of species, many given as new, illustrated by plates from photographs. The figures unfortunately lack detail in many cases. A short bibliography is given.

Cushman, Joseph A.

Foraminifera of Tropical Central Pacific.

(Bernice P. Bishop Museum Bulletin No. 27, Tanager Exped. Publ. No. 1, 1925, pp. 121-144.) *Honolulu.*

The foraminifera noted are those from the Tanager Expedition between Hawaii and Midway Island, a region little known. There are new species of *Uvigerina* and *Discorbis.*

Stipp, Thomas F.

The Relation of Foraminifera to the Origin of California Petroleum.

(Bull. Amer. Assoc. Petr. Geol., vol. 10, No. 7, July 1926, pp. 697-702.) *Chicago.*

A discussion of the question of diatoms or foraminifera as the source of the petroleum of California with the author tending toward the diatoms as the more likely source.

J. A. C.

CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

VOL. 2, PART 4, JANUARY 1927

33. SOME NEW GENERA OF THE FORAMINIFERA

By Joseph A. Cushman

In the closer study of several genera it has become increasingly apparent that some of these include species that have different developments with definite phylogenetic relationships, and as such should be separated from one another. Several generic names are therefore proposed for these different groups for the benefit of greater definiteness and to show better the relationships.

Genus PLANOGLOBULINA Cushman, new genus

Genotype, *Planoglobulina acervulinoides* (Egger) (*Guembelina acervulinoides* Egger)

Test with the earliest chambers in the microspheric form planispiral, followed by a series arranged biserially and in the adult by a series of globular chambers spread out fan-shaped or even partially extending back toward the earlier chambers on either side, the later chambers in a single plane; wall calcareous, perforate.

This genus represents an end form developed from *Pseudotextularia* Rzehak which in its earlier stages is similar, but in the adult has the chambers in a coiling series about the apertural end. Both genera are characteristic of the Upper Cretaceous of Europe and America.

Genus SPIROPLECTOIDES Cushman, new genus

Genotype, *Spiroplecta rosula* Ehrenberg, Mikrogeologie, 1854, pl. 32 (2), fig. 36.

Test with the early chambers planispiral, later ones biserial, the test elongate, sides nearly parallel and the biserial chambers very numerous; wall calcareous, finely perforate; aperture elliptical, terminal or nearly so in the adult.

Ehrenberg described this species from the Upper Cretaceous of America. I have lately had specimens from the Upper Cretaceous of Texas and Mexico which are evidently identical with Ehrenberg's species. The genus *Heterohelix* afterward changed to *Spiroplecta* by Ehrenberg has as its type *H. americana* Ehrenberg with planispiral young but the later chambers as in *Guembelina,* a genus derived from it.

Genus SPIROPLECTINA Cushman, new genus

Genotype, *Textularia annectens* PARKER and JONES, Ann. Mag. Nat. Hist., ser. 3, vol. 11, 1863, p. 92, fig. 1 (in text).

Test with the early chambers planispiral, later ones biserial, sides of the test straight and nearly parallel, the last group of chambers uniserial with distinctly constricted necks and a rounded, terminal aperture.

The specimens from the Cretaceous (Gault) show the uniserial adult stage, and probably represent an end stage developing from *Spiroplectoides.* Many arenaceous biserial forms have been referred to *Spiroplecta,* but they should be referred elsewhere.

Genus TUBULOGENERINA Cushman, new genus

Genotype, *Textularia* (*Bigenerina*) *tubulifera* PARKER and JONES, Ann. Mag. Nat. Hist., ser. 3, vol. 11, 1863, p. 94, fig. 2 (in text).

Test with the early chambers biserial, later ones uniserial, compressed or rounded in transverse section; wall with numerous tubuli extending out from the test either open, forming a tubular connection with the interior, or closed, forming lobular connections with the chambers; wall calcareous; aperture elongate, narrow, or in the adult with numerous rounded openings in the terminal face, the interior of the chambers at least in some species with a curved structure from roof to floor.

This genus occurs in the Upper Eocene of the Paris Basin and in the Miocene of Australia. It was originally figured in the above reference from Grignon by Parker and Jones. Later Terquem in 1882 (Mém. Soc. Géol. France, ser. 3, vol. 2, p. 121, pl. 12, figs. 35 *a, b*) referred it to *Clavulina cocenica* Gümbel. Heron-Allen and Earland (Journ. Roy. Micr. Soc., 1909, p. 329, pl. 16, fig. 1) had a specimen from the Eocene of Selsey, and recognizing that Terquem's placing of the species was erroneous, gave it a new name *Bigenerina conica* not recognizing the earlier name of Parker and Jones. Heron-Allen and Earland place under *B. conica* much larger specimens from the Miocene of Aus-

tralia (Pl. 16, figs. 2-6) which from a study of specimens in my own collection from the Filter Quarry of Moorabool River and comparison with *T. tubulifera* from the Eocene of the Paris Basin appear to be a different species. The Australian species is much larger, has the biserial development much more restricted, the rows of tubules two or three in the adult, whereas they are usually single in the Eocene species. This Australian Miocene species may be known as *Tubulogenerina mooraboolensis* Cushman, new species. Other species are *Tubulogenerina ferox* (Heron-Allen and Earland) from the same locality and *T. papillosa* (Halkyard) from the Eocene of Biarritz.

Genus BOLIVINELLA Cushman, new genus

Genotype, *Textularia folium* PARKER and JONES, Phil. Trans., vol. 155, 1865, pp. 370, 420, pl. 18, fig. 19.

Test much compressed, the proloculum in the megalospheric form rectangular, in the microspheric form the young is apparently planispiral, later chambers biserial; chambers long and recurved, not overlapping; wall calcareous, perforate; aperture transverse to the compression of the test with numerous papillae at the base of the opening.

This genus is most nearly related to *Guembelina* and its allies. It occurs as far back as the Eocene, and continues to the present ocean where it is found in the Indo-Pacific. Besides *Bolivinella folium* (Parker and Jones) there are other species occurring both fossil and in the present ocean.

Genus NODOGENERINA Cushman, new genus

Genotype, *Nodogenerina bradyi* CUSHMAN, new species

Test uniserial, straight; chambers increasing in size as added, distinct, inflated, constricted at the connection between the chambers; wall calcareous, finely perforate; aperture terminal, central, rounded, with a cylindrical neck and phialine lip.

NODOGENERINA BRADYI Cushman, new species

Sagrina virgula H. B. BRADY (in part), Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, pl. 76, fig. 8 (not 4-6, 9, 10).

Test uniserial; chambers increasing in size as added, inflated, widest near the base, which is finely spinose, lower portion rapidly constricted; wall smooth except at the basal ridge, finely perforate; aperture rounded or elliptical, with a short neck and slightly flaring phialine lip.

Brady does not give the locality for this specimen although

those figured on the same plate, figs. 9, 10, came from off the Ki Islands.

The genus resembles *Nodosaria* in its superficial characters, but is not glassy, and does not have a radiate aperture. It is a derivative as an end form from *Siphogenerina.*

Genus NODOMORPHINA Cushman, new genus

Genotype, *Nodosaria compressiuscula* NEUGEBOREN, Verh. Mitth. Siebenburg. Ver. Nat., vol. 3, 1852, p. 59, pl. 1, figs. 54-56; Denkschr. Akad. Wiss. Wien, vol. 12, pt. 2, 1926, p. 79, pl. 2, figs. 1-7.

Test compressed, especially in the earlier portion; chambers numerous, early ones quadrilateral in section, later ones more nearly circular; sutures distinct, slightly depressed, especially between the later chambers; wall ornamented by numerous raised costae in pairs one at either side of the median line giving a bilateral symmetry to the test; aperture circular or elliptical without teeth or radiate fissures, terminal.

This genus includes those forms figured above. *Nodomorphina compressiuscula* may be distinguished from *Nodosaria* by the lack of a radiate aperture and by the paired character of the costae making up the ornamentation and compressed test. It is an end form developed through *Plectofrondicularia* and *Amphimorphina.*

Genus CRIBROBULIMINA Cushman, new genus

Plate 11, figs. 1-5

Genotype, *Valvulina mixta* PARKER and JONES, in Carpenter, Parker and Jones, Introd. Foram., 1862, p. 146, pl. 11, fig. 19.

Test in the early stages trihedral, angled, the sides flattened; chambers triserially arranged, adult chambers in a loose spiral, five or more in a coil; sutures distinct; wall arenaceous; aperture in the young as in *Valvulina* later developing an opening in the plate-like tooth, and in the adult a series of small openings forming a cribrate plate, (pl. 11, fig. 5).

The type species, *Cribrobulimina mixta* (Parker and Jones) is from Australia. It develops from an angular verneuiline form while the next genus came from a rounded one and is more accelerated.

Genus ARENOBULIMINA Cushman, new genus

Genotype, *Bulimina presli* REUSS, Verstein Böhm. Kreide, 1845-46, pt. 1, p. 38, pl. 13, fig. 72.

Test with the earlier chambers triserial, the angles rounded,

later chambers spirally arranged, close coiled; sutures distinct, not depressed, of fine calcareous cement; wall finely arenaceous, smoothly finished; aperture with a broad rounded tooth.

Arenobulimina presli (Reuss) occurs in the Upper Cretaceous of Europe with other related species. I have for study a set of this species named and selected by Reuss himself, and they show even better than the published figures the differences between this and the calcareous, finely perforate, thin walled *Bulimina.*

Genus PSEUDOUVIGERINA Cushman, new genus

Genotype, *Uvigerina cristata* MARSSON, Mitth. Nat. Ver. Neu-Vorpommern u. Rügen, Jahrg. 10, 1878, p. 150, pl. 3, figs. 20 *a-c.*

Test in the early stages biserial, later triserial; wall calcareous, coarsely perforate; aperture with a tubular neck and phialine lip.

Pseudouvigerina cristata (Marsson) is one of the species which have apparently originated from the triserial condition foreshadowed by *Eouvigerina.* There are a number of very small species in the Upper Cretaceous of Europe and America which evidently arose in this manner and should not be confused with the later developed group represented by *Uvigerinella* Cushman and *Uvigerina* d'Orbigny which are apparently a direct derivation from *Bulimina.* The squarish periphery seen in *Eouvigerina cretacea* (Heron-Allen and Earland) and *E. americana* Cushman is seen in *Pseudouvigerina cristata* (Marsson) and in some of the American Cretaceous species. All the species noted are angular in character.

34. SOME ARENACEOUS FORAMINIFERA FROM THE UPPER CRETACEOUS OF TEXAS

By JOSEPH A. CUSHMAN and JAMES A. WATERS

A study of the species of the Upper Cretaceous of Texas has resulted in the finding of numerous species of arenaceous foraminifera. As there are certain zones especially in the Navarro formation where few other forms occur, it has seemed best to

describe a number of these. After a careful search of the literature nearly all these species seem to be undescribed in spite of the fact that so many of the calcareous Upper Cretaceous species of Texas and Mexico are identical with European ones. The arenaceous species considered here, belong to the genera *Proteonina, Reophax, Haplophragmoides* and *Trochammina.*

PROTEONINA DIFFLUGIFORMIS (H. B. Brady)

Plate 10, fig. 1

Reophax difflugiformis H. B. BRADY, Quart. Journ. Micr. Sci., vol. 19, 1879, p. 51, pl. 4, figs. 3 *a, b;* Rep. Voy. *Challenger,* Zoology, vol. 9, 1884, p. 289, pl. 30, figs. 2-4 (not 1, 5).

Proteonina difflugiformis RHUMBLER, Arch. Prot., vol. 3, 1903, p. 245, figs. 80 *a, b* (in text).—CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 1, 1910, p. 42, figs. 40, 41 (in text).

Test a single elongate oval or pyriform chamber with a more or less distinct tubular neck usually tapering gradually from the body of the chamber, undivided; wall fairly thick, of sand grains of variable size, firmly cemented; aperture circular, simple, terminal. Length up to 0.5 mm.

Just east of Richland, specimens occurred in the Navarro formation in cores from Navarro County, Texas. In some of these specimens, the neck is more pronounced than in the figured specimen.

REOPHAX TEXANA Cushman and Waters, new species

Plate 10, fig. 2

Test generally rectilinear, uniserial; the chambers spherical or nearly so, slightly overlapping; wall coarsely arenaceous of angular sand grains with the cement mostly inconspicuous; aperture small, rounded or angular, central, terminal. Length up to 1.25 mm.; diameter 0.50 mm.

Holotype (Cushman Coll. No. 6087) from Navarro formation, east of Richland, Navarro County, Texas.

This species is widely distributed in the Navarro formation breaking easily at the sutures so that complete specimens are rare, single chambers or two chambered fragments being most frequently met with.

HAPLOPHRAGMOIDES EXCAVATA Cushman and Waters, new species

Plate 10, figs. 3 *a, b*

Test close coiled, planispiral, compressed, periphery subacute;

chambers distinct, ten in the last-formed coil in the adult, the borders of each chamber distinctly thickened, central portion depressed; sutures straight, radial, not usually distinct; wall finely arenaceous with little cement, smoothly finished; color light gray. Length 0.45-0.50 mm; breadth 0.35-0.40 mm.; thickness 0.15-0.18 mm.

Holotype (Cushman Coll. No. 6089) from Navarro formation, near Quinlan, Hunt Co., Texas.

This is a common species especially in the upper part of the Navarro where it is often almost the only species present in certain zones.

HAPLOPHRAGMOIDES RUGOSA Cushman and Waters, new species
Plate 10, figs. 4 *a, b*

Test close coiled, planispiral, only slightly compressed, deeply umbilicate, periphery broadly rounded; chambers about 7 in the last-formed coil, subspherical; sutures slightly depressed, radial; wall coarsely arenaceous, of coarse but rather neatly fitted angular sand grains, usually dark colored. Diameter 0.50-0.60 mm.

Holotype (Cushman Coll. No. 6088) from the Navarro formation just east of Richland, Navarro County, Texas.

In some respects this resembles most closely some of the fossil forms referred to *H. canariensis* (d'Orbigny). It is very distinct from that species however.

HAPLOPHRAGMOIDES CALCULA Cushman and Waters, new species
Plate 10, figs. 5 *a, b*

Test close coiled, planispiral, very strongly compressed, sometimes slightly lobulated; chambers and sutures usually indistinct except in exceptional specimens; wall very coarsely arenaceous, roughly finished in spite of the considerable amount of cement; color dark greenish black. Length 0.67-0.75 mm.; thickness 0.18-0.20 mm.

Holotype (Cushman Coll. No. 6090) from the Navarro formation from dug well at Tona School, near Quinlan, Hunt Co., Texas, collected by Mrs. Helen J. Plummer.

The species seems rather limited in its vertical distribution, and varies very little in its general characters.

HAPLOPHRAGMOIDES GLABRA Cushman and Waters, new species
Plate 10, figs. 6 *a, b*

Test close coiled, planispiral, somewhat compressed and um-

bilicate, periphery rounded; chambers fairly distinct, 9-11 in the last-formed coil in the adult, rounded, evenly curved; sutures slightly curved, slightly depressed; wall finely arenaceous, smoothly finished; color dark gray. Length of type specimen 0.33 mm.; breadth 0.30 mm.; thickness 0.14 mm.

Holotype (Cushman Coll. No. 6091) from Navarro formation, Hunt Co., Texas.

While this species occurs with *H. excavata* it is a very different species.

TROCHAMMINA DIAGONIS (Carsey)

Plate 10, figs. 7 *a-c*

Haplophragmoides diagonis CARSEY, Univ. of Texas Bull. 2612, 1926, p. 22, pl. 3, fig. 1.

Test trochoid, compressed, periphery lobulated; chambers distinct, 6 or 7 in the last-formed coil; sutures distinct, depressed, on the dorsal side slightly curved, on the ventral side nearly radial; wall arenaceous with considerable cement. Diameter 0.65-0.80 mm.

This species was described as a *Haplophragmoides,* but a study of a large series of specimens including some from the type locality seems to show that the form is trochoid. The last-formed coil is sightly below the preceding one so that when shearing takes place as is frequent in this formation, there is a tendency for the specimens to show a peculiar irregular appearance. Well preserved specimens like that figured are found with those which have been subjected to strain and connect the two. The figured specimen (Cushman Coll. No. 6092) is from the Navarro formation, from core at Mexia, Limestone Co., Texas.

TROCHAMMINA GYROIDES Cushman and Waters, new species

Plate 10, figs. 8 *a, b*

Test trochoid, thick, dorsal side flattened, ventral side strongly convex, periphery subacute; chambers distinct, usually 6 in the last-formed coil; sutures less distinct on the dorsal side where they are very slightly depressed and gently curved, on the ventral side deeply depressed and radial; wall arenaceous with much cement, smoothly finished; aperture ventral, narrow. Diameter 0.65 mm.

Holotype (Cushman Coll. No. 6093) from Navarro formation, east of Richland, Navarro County, Texas.

This species is much the thickest of those described. It varies

somewhat having the chambers occasionally more loosely arranged.

TROCHAMMINA TEXANA Cushman and Waters, new species

Plate 11, figs. 8 *a-c*

Test trochoid, much compressed, plano-convex, dorsal side flat or even slightly concave, ventral side slightly convex, umbilicate; chambers fairly distinct, 6 in the last-formed coil, the later ones more distinct, the earlier ones much less so, the borders of the last chambers raised on the dorsal side, the central portion of each concave, on the ventral side the greatest thickness near the umbilical angle of each chamber; sutures on the dorsal side indistinct except between the last two or three chambers, on the ventral side distinct and depressed; wall very finely arenaceous, smoothly finished. Diameter 0.55 mm.

Holotype (Cushman Coll. No. 6094) from the Navarro formation, Tona School near Quinlan, Hunt Co., Texas, collected by Mrs. Helen J. Plummer.

This species resembles *Haplophragmoides excavata* somewhat in the last chambers and the texture of the test. It is typically a *Trochammina* however.

35. AMERICAN UPPER CRETACEOUS SPECIES OF BOLIVINA AND RELATED SPECIES

By Joseph A. Cushman

Many of the Upper Cretaceous species of Europe and America are identical, and others while they may be distinguished in one area from the other are nevertheless closely related. A study of the species usually assigned to *Bolivina* shows this same relationship. I am indebted to several European workers for excellent sets of Cretaceous species from the type formations from which they were described. It has thus been possible to make accurate comparisons of material from the two areas. Ehrenberg apparently figures species of *Bolivina* on Plate 32 of his Mikrogeologie which is entirely of American Cretaceous species.

None of them show the exterior however, and it is difficult to place them.

There are several different genera which may be recognized in the Upper Cretaceous, and these are described here. The species have very definite vertical ranges, and make excellent markers for correlation purposes.

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA INCRASSATA Reuss

Plate 12, figs. 1 *a*, *b*

Bolivina incrassata REUSS, Haidinger's Nat. Abhandl., vol. 4, 1851, p. 29, pl. 4, fig. 13; Sitz. Akad. Wiss. Wien, vol. 44, pt. 1, 1861 (1862), p. 332.—EGGER, Abhandl. kön. bay. Akad. Wiss. München, Cl. II, vol. 21, pt. 1, 1899, p. 45, pl. 16, figs. 4, 5; Sitz. kön. bay. Akad. Wiss. München, 1909, p. 23, pl. 1, fig. 18.—FRANKE, Abhandl. geol. pal. Instit. Univ. Greifswald, vol. 6, 1925, p. 21, pl. 2, fig. 8.—CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 19, pl. 2, figs. 1 *a*, *b*.

This smooth species I have already recorded from the Upper Cretaceous of Mexico where it is very common in the upper part of the Mendez shale. From the United States I have specimens from the Upper Cretaceous of Bartons Bluff, Tombigbee River, Ala., from the Navarro of Texas N. W. of Annona, Red River Co., and east of Richland, Navarro Co., and its occurs in the Annona Chalk, 10 miles N. E. of Dekalb, Bowie Co., Texas. The American specimens are identical with those from north central Europe.

BOLIVINA INCRASSATA Reuss, var. LIMONENSIS Cushman

Bolivina incrassata REUSS, var. *limonensis* CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 19, pl. 2, fig. 2.

This elongate variety described from the Mendez shale of Mexico has not been found in the material I have had from the United States.

BOLIVINA TEGULATA Reuss

Plate 12, fig. 2

Bolivina tegulata REUSS, Haidinger's Nat. Abhandl., vol. 4, 1851, p. 29, pl. 4, fig. 12.—EGGER, Abhandl. kön. bay. Akad. Wiss. München, Cl. II, vol. 21, pt. 1, 1899, p. 45, pl. 16, figs. 10, 11.—FRANKE, Abhandl. geol. pal. Instit. Univ. Greifswald, vol. 6, 1925, p. 21, pl. 2, fig. 7.

Bolivina textilarioides REUSS, Sitz. Akad. Wiss. Wien, vol. 46, pt. 1, 1862 (1863), p. 81, pl. 10, fig. 1.

Test slender, much elongate, about 4 times as long as broad,

gradually tapering to the greatest breadth near the apertural end, periphery broadly rounded; chambers numerous, often 20 or more in the adult, slightly inflated, higher than broad; sutures distinct, nearly at right angles to the periphery, very slightly depressed; wall smooth, finely perforate; aperture elongate, narrow.

Length 0.45 mm.; breadth 0.12 mm.; thickness 0.08 mm.

There are numerous records for this species in the European Cretaceous, but it seems to be less common in America. I have it from the Upper Cretaceous of Bartons Bluff, Tombigbee River, Ala., and from material collected by Mrs. Helen J. Plummer as follows: Navarro formation, ½ mile S. of Kemp, Texas; Taylor marl, Clay pit of Dallas Brick Co., ½ mile west of Mesquite, Texas, and Brownstown marl, RR. cut ½ mile W. of Okolona, Arkansas.

BOLIVINA GEMMA Cushman, new species

Plate 12, figs. 3 *a*, *b*

Test elongate, rather stout, slightly tapering, somewhat twisted, periphery rounded; chambers 17 or more in the adult, distinct, slightly inflated, nearly as high as broad in the adult; sutures very distinct, somewhat limbate, very slightly depressed near the periphery, the inner margins raised, forming a row of beadlike ornamentations of clear shell material, finely striate; wall thick, opaque, very finely perforate; aperture elongate, elliptical.

Maximum length 1 mm.; breadth 0.30 mm.; thickness about 0.12 mm.

Type specimen from the Upper Cretaceous, Arkadelphia clay, 7 miles W. of Hope, Hempstead Co., Arkansas.

The species is a common one in the American Cretaceous occurring in the Navarro formation of Texas and in the Brownstown marl of Arkansas.

BOLIVINA CLAVATA Cushman, new species

Plate 12, figs. 5 *a*, *b*

Test elongate, very tapering, club-shaped, the last-formed portion nearly circular in section, periphery rounded, 23 or more chambers in the adult; chambers fairly distinct, somewhat inflated, especially in later growth, the lower margin with backward projecting, short, blunt lobes with depressed areas be-

tween; sutures fairly distinct, slightly depressed, earlier ones at right angles to the periphery; wall finely perforate, earlier chambers finely pitted in longitudinal lines; aperture ovate.

Length 0.60 mm.; breadth 0.20 mm.; thickness 0.16 mm.

Holotype (Cushman Coll. No. 5272) from Upper Cretaceous, Taylor marl, Clay pit of Dallas Brick Co., ½ mile W. of Mesquite, Texas, collected by Mrs. Helen J. Plummer.

It occurs also in the Navarro in Limestone and Navarro Counties, Texas.

BOLIVINA VELASCOENSIS Cushman

Bolivina velascoensis CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, 1926, p. 586, pl. 16, figs. 1 *a*, *b*.

This species is only known from the Upper Cretaceous, Velasco shale of Mexico.

BOLIVINA DECURRENS (Ehrenberg)

Plate 12, fig. 4

Grammostomum decurrens EHRENBERG, Mikrogeologie, 1854, pl. 30, fig. 17.

Bolivina decurrens MARSSON, Mitth. Nat. Ver. Neu-Vorpommern u. Rügen, vol. 10, 1878, p. 156, pl. 3, fig. 24.—FRANKE, Abhandl. geol. pal. Instit. Univ. Greifswald, vol. 6, 1925, p. 20, pl. 2, fig. 6.

The only American specimens of this species I have are from the Upper Cretaceous, Navarro formation, E. of Richland, Navarro Co., Texas. It is a small species and may easily be overlooked.

BOLIVINA WATERSI Cushman, new species

Plate 12, fig. 6

Test minute, tapering, broadest near the apertural end, thickest along the median line, periphery subacute; chambers very distinct, numerous, curved; sutures distinct, depressed, with broad depressions between the chambers; wall rather coarsely perforate; aperture narrow, elongate.

Length 0.25 mm.; breadth 0.10 mm.

Holotype (Cushman Coll. No. 6119) from the Upper Cretaceous, Navarro formation, E. of Richland, Navarro Co., Texas.

This species is very small and easily overlooked, but the characters are very distinctive. It is named for Mr. James A. Waters who discovered it.

Genus **PROROPORUS** Ehrenberg, 1844

Proroporus Ehrenberg, Ber. k. pr. Akad. Wiss. Berlin, 1844, p. 75. (Genotype, *P. lingua* Ehrenberg).

Test biserial and like *Bolivina* except that in the adult the chambers tend to extend clear across the test, and the aperture becomes terminal.

The typical characters call for a biserial test with a terminal aperture. This is a stage toward *Bifarina,* but may be a convenient one to recognize.

PROROPORUS PLAITA (Carsey)

Plate 12, figs. 7 *a, b*

Bolivina plaita Carsey, Univ. Texas Bull. 2612, 1926, p. 26, pl. 4, fig. 2.

The type specimens of this smooth species are from the Upper Cretaceous of Texas. Mrs. Carsey has kindly sent me typical specimens of this species. In my own collection I have the species from numerous localities especially from the Navarro of Texas, and a form of it also occurs in the Taylor marl. Very excellent specimens were collected by Mrs. Helen J. Plummer from the Ripley formation of Owl Creek, Miss. The aperture in adult specimens becomes terminal which would place the species in the genus *Proroporus.* It is very close to *Bolivina reussi* Geinitz from the Upper Cretaceous of Europe, and may prove to be the same.

Genus **BOLIVINOIDES** Cushman, new genus

The species taken for the genotype of this genus is *Bolivina draco* Marsson from the Upper Cretaceous of Europe. In this and related species from the Upper Cretaceous of Europe and America there is a generally rhomboid test with the thickest portion toward the aperture, this end of the test usually appearing like a thickened lip devoid of ornamentation. The sutures and chamber divisions are more or less obscured by the ornamentation which is in general at right angles to the sutures, and represented by costae or raised lobes of the test. Such species are widely distributed in the Upper Cretaceous of Europe and America, but apparently did not persist into the Tertiary.

BOLIVINOIDES DECORATA (Jones)

Plate 12, fig. 9

Bolivina decorata Jones, in Wright, Proc. Belfast Nat. Field Club, Appendix, 1885-86, p. 330, pl. 27, figs. 7, 8.
Bolivina latticea Carsey, Univ. Texas Bull. 2612, p. 27, pl. 4, fig. 9.

This species described by Jones from the Cretaceous of Keady

Hill, County Derry, Ireland, occurs also in the Upper Cretaceous of America. The apertural end of the test is thickened, and the whole test generally rhomboid in front view, the sutures obscured by the surface ornamentation consisting of prominent oblong tubercles arranged so that there is an apparent crossing of two sets of broken ridges.

Mrs. Carsey has kindly sent me a specimen of her species which seems to be identical with that of Jones. Her specimens are from the Taylor marl, 4 miles S.W. of Taylor, Texas. I have the species also from the Taylor, 1.8 miles N.W. of Annona, Red River Co., and from the Annona Chalk, 10 miles N. by E. of Dekalb, Bowie Co., Texas.

BOLIVINOIDES DECORATA (Jones), var. DELICATULA Cushman, new variety

Plate 12, fig. 8

Bolivina decorata CUSHMAN (not Jones), Bull. Amer. Assoc. Petr. Geol., vol. 10, 1926, p. 582, pl. 15, fig. 11.

Test differing from the typical in the much more slender test, the ornamentation being much less definitely marked, the wall thinner and fairly smooth toward the initial end.

Holotype of variety (Cushman Coll. No. 5139) from the Upper Cretaceous, Velasco shale of Hacienda El Limon, Vera Cruz, Mexico. It also occurs in the Navarro formation of Texas as well as in the upper part of the Taylor marl. It is closely related to *Bolivinoides strigillata* (Chapman) from the Upper Cretaceous of England.

BOLIVINOIDES RHOMBOIDEA (Cushman)

Plate 12, figs. 10 *a*, *b*

Bolivina rhomboidea CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 19, pl. 2, figs. 3 *a*, *b*.

This species described from the Upper Cretaceous, Mendez shale, of Mexico does not seem to occur in the more northern localities. It is closely related to *B. decorata* (Jones) and even more closely to *B. draco* (Marsson). It is a shorter more rhomboid form than either, and the ornamentation is much coarser and more definite.

Genus BOLIVINITA Cushman, new genus

The species taken as the genotype of this genus is *Bolivinita quadrilatera* (Schwager). A species, *Bolivinita eleyi* Cushman, new species, is known from the Cretaceous of Europe and Amer-

ica. There are probably other species including *Bolivinita rhomboidalis* (Millett). The chambers of the test are alternating, but the periphery is concave with strongly developed angles which are carinate, giving a quadrilateral or rhomboid form in section and end view. The aperture is broader than is usual in *Bolivina* being much more like that of *Guembelina* to which it is related. The general characters have persisted since the Upper Cretaceous, and as might be suspected from other similar examples, the living species are today most abundant and strongly developed in the Indo-Pacific.

BOLIVINITA ELEYI Cushman, new species

Plate 12, figs. 11 *a*, *b*

Textularia obsoleta ELEY (not Reuss), Geol. in the Garden, 1859, p. 202, pl. 8, fig. 11 C; (?) p. 195, pl. 2, fig. 11.—WRIGHT, Irish Nat., 1902, p. 179, list.—(?) CHAPMAN, Bull. Geol. Surv., W. Australia, No. 72, 1917, p. 16, pl. 12, fig. 116.

Test somewhat rhomboid, two or three times as long as broad, greatest width formed by the last two chambers, the periphery flattened as are the other two broader faces, angles very slightly keeled; sutures somewhat indistinct, limbate; surface finely perforate.

This species was originally described by Eley from the Cretaceous Chalk of England. It is not the same as the earlier described *Textularia obsoleta* Reuss, and must have a new name. I have therefore named it *Bolivinita eleyi*.

Holotype (Cushman Coll. No. 5552) from the upper part of the Brownstown marl, Hollywood road, 8.1 miles W. of Arkadelphia, Clark Co., Arkansas collected by L. W. Stephenson. This is apparently identical with the English Chalk species. Chapman has recorded *Bolivina obsoleta* from the Cretaceous, Gingin Chalk of Australia, noting that the Cretaceous specimens are narrower than those of the Pliocene or Recent which have been referred to the same species.

36. THE SIGNIFICANCE OF RELATIVE MEASUREMENTS IN THE STUDY OF FORAMINIFERA

By Joseph A. Cushman and Reginald W. Harris

The variation in size of foraminifera has long been a subject of note by many authors. Small forms are often referred to as "starved" forms or varieties without any data from an experimental point of view to prove the validity of this idea. To determine what might be shown over a wide range of distribution in a species where no doubt as to the specific identification would be involved, a study was made of several series of *Pulvinulina menardii* (d'Orbigny) from various depths and localities. Series from the Western Atlantic were used, care being taken to see that the material had not been previously sorted by sifting or other treatment. Also care was taken to use what appeared to be adult specimens in all cases. Five localities from *Albatross* dredgings were taken as follows: D 2763, off Southern Brazil 24° S., 42° W., 671 fathoms; D 2760 off Eastern Brazil, 12° S., 37° W., 1019 fathoms; H 165, Caribbean Sea, 15° 55′ N., 71° 03′ W., 2209 fathoms; D 2381, Gulf of Mexico, 28° 05′ N., 87° 56′ 15″ W., 1330 fathoms; D 2041, off New England, 39° 22′ N., 68° 25′ W., 1608 fathoms. A series of specimens were measured for length and breadth as follows, the figure given being the average.

D 2763,	Length	.957	mm.,	breadth	.744	mm.
D 2760,	"	1.067	"	"	.873	"
H 165,	"	1.252	"	"	1.024	"
D 2381,	"	1.190	"	"	.984	"
D 2041,	"	1.139	"	"	.902	"

A study of the figures shows that the maximum size is reached in the Caribbean Sea, and a progressive decrease in size takes place both north and south. Due possibly to the effect of warm Gulf Stream water, size falls off less rapidly toward the north than toward the south. Several series were measured from various parts of the Pacific, but none of them approach the size attained in the Caribbean and Gulf of Mexico.

In the Miocene of Trinidad, specimens close to or identical with *Pulvinulina menardii* are common in the *Globigerina*-ooze. A series of these gives the following average measurements: length .565 mm.; breadth .492 mm. It will be noted that these are

very much smaller than the recent specimens, and indicate that the species has been growing larger in late Tertiary time.

To carry this idea further, a series of specimens of *Textularia* of various species all allied to d'Orbigny's *T. carinata* were measured with the following general results. Of these species, *Textularia mississippiensis* Cushman from the Upper Eocene and Lower Oligocene of America shows apparently that the size has increased somewhat from the Upper Eocene through the Red Bluff Clay to the Byram Marl of the Lower Oligocene, where the largest specimens were found. In Europe in the Oligocene and Miocene, *Textularia carinata* d'Orbigny from the specimens measured, shows a progressive increase reaching its maximum in the Miocene. The recent *T. pseudocarinata* Cushman, while related to the Miocene species of d'Orbigny, is much smaller as well as differing in other characters. This particular group of related species which had its inception in the Early Tertiary, apparently reached the maximum size in the Miocene of Europe.

A series of *Pulvinulina mexicana* Cushman, *P. jacksonensis* Cushman and Applin, and *P. byramensis* Cushman from the Claiborne, Jackson and Byram Marl respectively were measured and compared. These species are closely related, and often difficult to distinguish, but the relative proportions with the other characters makes them readily identifiable. The following series were measured from large, well-preserved specimens:

P. byramensis (Byram, Miss.) Diameter .812 mm.; thickness .462 mm.

P. jacksonensis (Bunker Hill, Ouachita River, La.) Diameter .812 mm.; thickness .424 mm.

P. mexicana (Moctezuma River, Mexico.) Diameter .769 mm.; thickness .482 mm.

It will be noted that the average diameter varies but little, yet *P. mexicana* consistently averages less than the species from the horizons above. This was further checked by measurements of series of the *P. mexicana* from Louisiana, Texas, California and Mexico. The diameter of *P. jacksonensis* and *P. byramensis* averaged alike in these two series, yet the latter appears larger under the binocular, due to the greater thickness. The ventral side in the three species becomes more convex in relation to the total thickness as development in the geologic column takes place. Even the ratio of diameter and thickness shows this relation somewhat, although a further division of the thickness into dorsal and ventral would be much more striking. The following ratios of total thickness to total diameter were obtained:

P. byramensis, 1 : 1.75 or thickness 57.0% of diameter
P. jacksonensis, 1 : 1.92 or thickness 52.1% of diameter
P. mexicana, 1 : 1.60 or thickness 62.6% of diameter

Data on a small form of *Gyroidina soldanii* d'Orbigny, common in the Eocene and Oligocene were obtained. Specimens were fairly abundant, and only mature forms were used.

Zardo Creek, Mexico	diameter .28 mm.
Gonzales Co., Texas (Cook Mt.)	diameter .32 mm.
North Louisiana (Minden)	diameter .387 mm.

Specimens from the Jackson and the Red Bluff Clay of the Lower Oligocene show that the maximum size is reached in the Lower Oligocene with an average diameter of .433 mm. These relative measurements checked over a series extending to the Eocene of California.

The suggestion is here made that with a long-lived species or series of related species, it may be possible by the simple method of measuring a series of adult specimens to place the sample containing them in its relative position in the geologic column. A series of measurements made on such species, especially where material can be obtained from continuous core samples, should give valuable data along this line. Other characters of course should be taken into account, but relative measurements seem to hold a distinct possibility if used with full discrimination as to selection of material.

37. SPORADOGENERINA, A DEGENERATE FORAMINIFERAL GENUS

By Joseph A. Cushman

In the collection of slides of foraminifera made by the late Dr. James M. Flint is one containing several specimens of a very peculiar foraminifer from the Gulf of Mexico. Doctor Flint evidently recognized its unique character as the slide was labelled new but no name given. A study of the series shows that the specimens belong to a new species which cannot be placed in any described genus. For it a new genus is erected as follows:

Genus SPORADOGENERINA Cushman, new genus

Test with the early chambers roughly uvigerine especially in the microspheric form, the later chambers becoming irregularly uniserial and much elongate; aperture changing from a regular terminal position to one or more indefinite openings at the side of the chamber. Genotype, *Sporadogenerina flintii,* new species.

SPORADOGENERINA FLINTII Cushman, new species

Plate 11, figs. 6, 7

Test elongate, early chambers globular, arranged in an irregular spiral in the microspheric form, in the megalospheric form fewer and less regular; later chambers very irregular, elongate, subcylindrical, uniserial; sutures distinct, slightly depressed; wall thin, hyaline, finely perforate; aperture in the young simple, terminal, in the adult, one or more, often on the side of the chamber. Length up to 2 mm.

Holotype (U. S. Nat. Mus. No. 20283) from *Albatross* station D2377 in the Gulf of Mexico, 210 fathoms.

The early stages resemble those of species as *Uvigerina interrupta.* The smaller the proloculum, the greater the number of the uvigerine chambers. This genus is probably derived from a smooth form of *Uvigerina,* and is evidently a degenerate one.

EXPLANATION OF PLATE 10

FIG. 1. *Proteonina difflugiformis* (H. B. Brady). X 50.

FIG. 2. *Reophax texana* Cushman and Waters, n. sp. X 50.

FIGS. 3 *a, b*. *Haplophragmoides excavata* Cushman and Waters, n. sp. X 50.
a, side view; *b*, peripheral view.

FIGS. 4 *a, b*. *Haplophragmoides rugosa* Cushman and Waters, n. sp. X 50.
a, side view; *b*, peripheral view.

FIGS. 5 *a, b*. *Haplophragmoides calcula* Cushman and Waters, n. sp. X 50.
a, side view; *b*, peripheral view.

FIGS. 6 *a, b*. *Haplophragmoides glabra* Cushman and Waters, n. sp. X 50.
a, side view; *b*, peripheral view.

FIGS. 7 *a–c*. *Trochammina diagonis* (Carsey). X 50.
a, dorsal view; *b*, ventral view; *c*, peripheral view.

FIGS. 8 *a, b*. *Trochammina gyroides* Cushman and Waters, n. sp. X 50.
a, dorsal view; *b*, peripheral view.

EXPLANATION OF PLATE 11

FIGS. 1–5. *Cribrobulimina mixta* (Parker and Jones). X 30. Recent specimens from Australia. Fig. 1, apparently a megalospheric form with the later chambers loosely coiled, the aperture at the base of the chamber and another supplementary one in the face of the chamber; fig. 2, the secondary aperture enlarging, and in fig. 3, divided into several openings. Fig. 4, a broad microspheric form with the secondary openings grouped in a semicircle. Fig. 5, a large adult specimen with the cribrate plate having numerous scattered, rounded openings.

FIGS. 6, 7. *Sporadogenerina flintii* Cushman, n. sp. X 30.

FIGS. 8 *a–c*. *Trochammina texana* Cushman and Waters, n. sp. X 50.
a, dorsal view; *b*, ventral view; *c*, peripheral view.

EXPLANATION OF PLATE 12

FIGS. 1 *a, b*. *Bolivina incrassata* Reuss. X 35.
a, front view; *b*, side view.

FIG. 2. *Bolivina tegulata* Reuss. X 65.

FIGS. 3 *a, b*. *Bolivina gemma* Cushman, n. sp. X 65.
a, front view; *b*, side view.

FIG. 4. *Bolivina decurrens* (Ehrenberg). X 100.

FIGS. 5 *a, b*. *Bolivina clavata* Cushman, n. sp. X 65.
a, front view; *b*, side view.

FIG. 6. *Bolivina watersi* Cushman, n. sp. X 150.

FIGS. 7 *a, b*. *Proroporus plaita* (Carsey). X 65.
a, front view; *b*, side view.

FIG. 8. *Bolivinoides decorata* (Jones), var. *delicatula* Cushman, n. var. X 65.

FIG. 9. *Bolivinoides decorata* (Jones). X 65.

FIGS. 10 *a, b*. *Bolivinoides rhomboidea* (Cushman). X 65.
a, front view; *b*, end view.

FIGS. 11 *a, b*. *Bolivinita eleyi* Cushman, n. sp. X 65.
a, front view; *b*, side view.


1


2


3b


3a


5b


4a


4b


5a


6b


6a

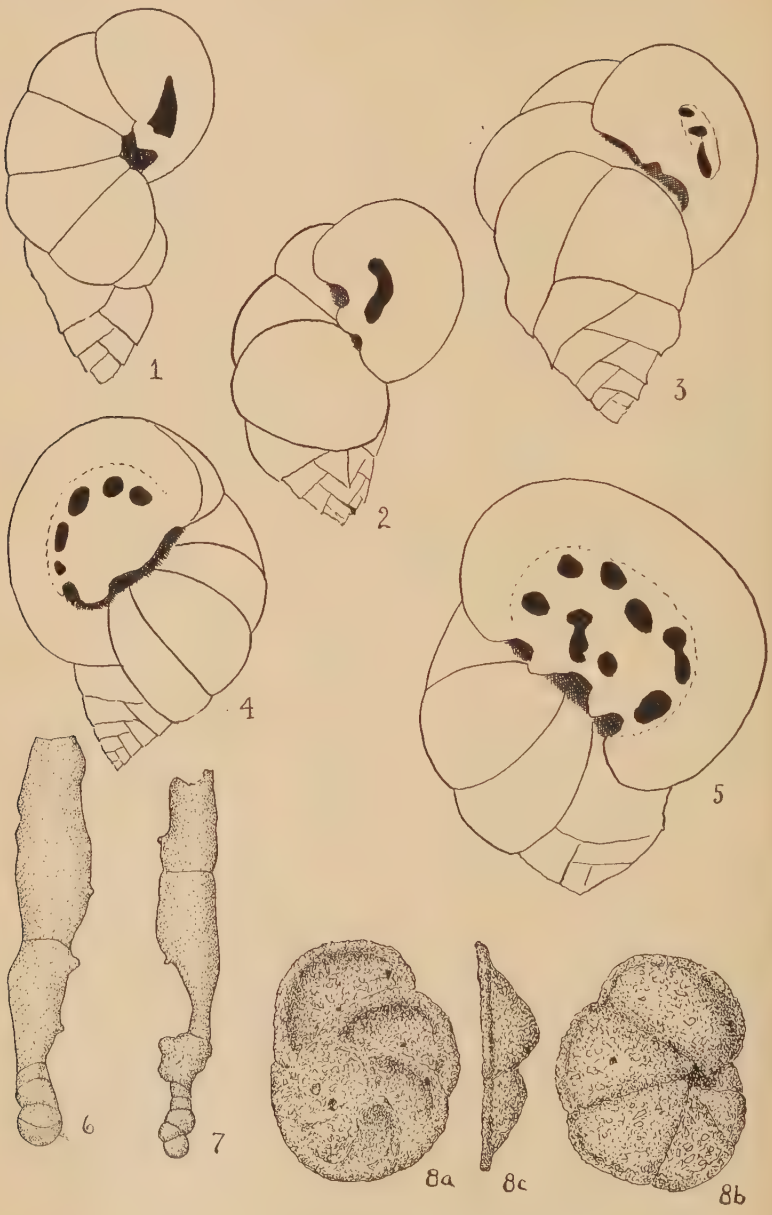

7c


7b


8a


8b


7a


1
2
3
4
5
6
7
8a
8c
8b


1a
1b
2
3a
3b
4
5a
5b
6
7a
7b
8
9
10b
10a
11a
11b

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the foraminifera that have come to hand.

Parr, Walter J.

Some Additional Microzoa from the Red Limestone at Grange Burn, Vic.

(Victorian Naturalist, vol. 43, May 1926, pp. 17-20.) *Melbourne.*

A list of 58 species and varieties of foraminifera and 4 of ostracods are given with notes on the more interesting species.

Milner, Henry B.

The Stratigraphic Value of Micro-Organisms in Petroleum Exploration.

(Nature (London), vol. 117, April 17, 1926, pp. 558-560.) *London.*

A summary of the work that has been done in America on the Cretaceous and Tertiary foraminifera and other groups, especially in connection with petroleum work on subsurface geology.

Douvillé, H.

La forme conique chez les Foraminiféres, et le genre Dictyoconus Nuttall.

(Compte Rend. Sommaire Seances Soc. Geol. France, 1926, pt. 3, pp. 19-21.) *Paris.*

The conical form in the different groups of foraminifera is discussed, and detailed notes on the genus *Dictyoconoides* are given.

Newton, R. Bullen.

On Fusulina and other Organisms in a partially Calcareous Quartzite from near the Malayan-Siamese Frontier.

(Ann. Mag. Nat. Hist., ser. 9, vol. 17, 1926, pp. 49-64, pls. 2, 3.) *London.*

Foraminifera as well as other fossils are noted, and an excellent bibliography of papers dealing with Palaeozoic foraminifera especially Fusulina and its allies is given.

Casasnovas, G. C.
Nota sobre las Amphistegina, Miogypsina y Lepidocyclina, del Burdigaliense de Malloica.
(Bol. R. Soc. Espan. Hist. Nat., vol. 26, No. 5, 1926, pp. 287-291, 4 text figs.) *Madrid.*
Numerous species are recorded by genera only.

Terra, H. de.
Ein neues Tertiärvoskommen im Kontinentalen Griechenland.
(Centralblatt für Min. Geol. u. Pal., abt. B, No. 8, 1926, pp. 265-271, 2 figures.) *Stuttgart.*
A new formation in the Tertiary of Greece is noted, and notes on several species of foraminifera are given.

Hodson, Helen K.
Names for the stellate "Orthophragmina."
(Amer. Journ. Sci., vol. 12, No. 70, October 1926, pp. 353, 354.) *New Haven.*
This paper shows that the name *Asteriacites* Schlotheim adopted for the stellate "*Orthophragmina*" cannot be used, and that the first name that can be used is *Cisseis* Guppy, 1866.

Yabe, Hisakatsu and Shoshiro Hanzawa.
A foraminiferous limestone, with a questionable fauna, from Klias peninsula, British North Borneo.
(Sci. Rept. Tohoku Imp. Univ., sec. ser. (Geol.), vol. 9, No. 1, 1926, pp. 1-7, plate 1.) *Sendai.*
Numerous species and genera are recorded and figured from a peculiar limestone which may represent a passage bed between the Eocene and Oligocene.

Yabe, Hisakatsu and Shoshiro Hanzawa.
Choffatella Schlumberger, and *Pseudocyclammina* a new genus of arenaceous foraminifera.
(Sci. Rept. Tohoku Imp. Univ., sec. ser. (Geol.), vol. 9, No. 1, 1926, pp. 9-11, plate 2, 1 text figure.) *Sendai.*
This paper deals with *Cyclammina*-like forms from the lowermost Cretaceous or Upper Jurassic of Japan. A new genus, *Pseudocyclammina,* is erected and a new species of *Choffatella* described.

Yabe, Hisakatsu and Shoshiro Hanzawa.

Geological age of *Orbitolina*-bearing rocks of Japan.

(Sci. Rept. Tohoku Imp. Univ., sec. ser. (Geol.), vol. 9, No. 1, 1926, pp. 13-20, pls. 3-6, 1 text figure.) *Sendai.*

Five new species and varieties of *Orbitolina* are described and figured from the Lower Cretaceous formations of Japan.

Hofker, J.

Die Foraminiferen aus dem senon Limburgens. V.

(Nat. Maan., Nat. Gen. Limberg, Jaarg. 15, No. 7, July 30, 1926, pp. 79-82, 1 plate.) *Limburg.*

A paper devoted to exhaustive descriptive details with numerous figures of *Amphistegina fleuriausi.*

Nuttall, W. L. F.

The Zonal Distribution and Description of the Larger Foraminifera of the Middle and Lower Kirthar Series (Middle Eocene) of Parts of Western India.

(Geol. Survey India, Records, vol. 59, 1926, pp. 115-164, pls. 1-8.) *Calcutta.*

Many details of distribution and correlation are given, with descriptive details of many species of *Nummulites, Assilina, Discocyclina* and *Actinocyclina*, a number of them new. Ten pages of bibliography are given. The paper is illustrated by exceptionally clear photographic sections and exteriors.

Gee, F. R.

The Geology of the Andaman and Nicobar Islands, with special reference to Middle Andaman Island.

(Records. Geol. Survey India, vol. 59, pt. 2, 1926, pp. 208-232, pls. 11-15.) *Calcutta.*

A very few genera of foraminifera are noted. The plates contain a figure of *Assilina granulosa* and some sections of unnamed Lepidocyclinas and Nummulites.

Davies, L. M.

Remarks on Carter's genus Conulites-dictyoconoides Nuttall with descriptions of some new species from the Eocene of North-West India.

(Rec. Geol. Survey India, vol. 59, pt. 2, 1926, pp. 237-253, 5 pls.) *Calcutta.*

Detailed description of the genus and of several new species from India are given with excellent photographic figures.

Lacroix, E.

De l'emploi des coccoliths par les Foraminiféres arénacés pour ' édification de leurs testes.

(Compt. Rend. Acad. Sci., vol. 183, pt. 7, 1926, pp. 430-431.) *Paris.*

Numerous species from the Rockall Bank use coccoliths in the building of the test. Solution by acid shows the usual chitinous lining, and chemical tests show the usual iron compounds present.

Gilard, P.

Recherche sur la constitution des craies du Limbourg.

(Acad. Roy. Belgique Cl. Sci. Mem. Coll., vol. 8, pt. 1, 1926, pp. 1-72, 4 pls., 8 text figs.) *Bruxelles.*

A few foraminifera are recorded by genera from these Cretaceous sediments of Belgium.

Chapman, Frederick.

Cretaceous and Tertiary Foraminifera of New Zealand with an Appendix on the Ostracoda.

(New Zealand Dept. Mines, Geol. Surv. Palaeont. Bull. No. 11, 1926, pp. 1-120, 22 pls.) *Wellington.*

This is an important paper taking in all the known Cretaceous and Tertiary Foraminifera of New Zealand. The original plates of Karrer and Stache on the *Novara*-Expedition collections from New Zealand are republished. There are 277 species and varieties of foraminifera, and 28 of ostracods. Eleven of the foraminifera are described as new, and five of the ostracods. The similarity of the Cretaceous to that of Europe and America is noted.

Nuttall, W. L. F.

The Zonal Distribution of the Larger Foraminifera of the Eocene of Western India.

(Geol. Mag., vol. 63, No. 749, Nov. 1926, pp. 495-504.) *London.*

A summary of the species that have been recorded from this region and their stratigraphic significance with tables showing distribution.

J. A. C.